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M. Y. Nuttonson

American Institute of Crop Ecology

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AICE* SURVEY OF USSR AIR POLLUTION LITERATURE

Volume XIX

ENVIRONMENTAL POLLUTION WITH SPECIAL REFERENCE TO AIR POLLUTANTS AND TO SOME OF THEIR BIOLOGICAL EFFECTS

Edited By

M. Y. Nuttonson

The material presented here is part of a survey of
USSR literature on air pollution
conducted by the Air Pollution Section
AMERICAN INSTITUTE OF CROP ECOLOGY

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*AMERICAN INSTITUTE OF CROP ECOLOGY
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PREFACE

The papers presented in this volume relate to a number of aspects of man's impact on the sanitary conditions of his physical environment. Most of the material deals with various problems of urban areas where the atmospheric air is polluted with noxious gaseous and solid impurities and where the health of the local population is endangered by the effects of ambient toxic substances.

A number of the papers of the present volume consist of surveys of sources of air pollution, of concentrations of various air pollutants, of measures aimed at improving the sanitary conditions in the air reservoir through preventive legislative actions of organizational as well as of technical character adopted in the USSR, and of the nature of investigations conducted at a network of the sanitary-epidemiological stations and laboratories of the country.

Some of the material of the other papers of this volume represents reports of experimental and field studies dealing with

(1) the physical and chemical factors in relation to the external and industrial environment,

(2) the adverse biological effects of various chemical substances discharged from industrial enterprises,

(3) the degree of pollution and nature of the noxious substances emitted into the atmosphere by ferrous metallurgical plants and by electric power plants, as well as the sanitary evaluation and sanitary recommendations for protecting the areas around these plants,

(4) the dynamics and concentration of various hydrocarbons discharged from gas-processing plants into the atmospheric air in relation to meteorological factors,

(5) the sanitary standardization of ambient chemical toxic substances and their maximum permissible concentrations.

The results of the above studies provide in the USSR a basis and a scientific criteria for assessing the degree of air pollution and form the foundation for a number of proposed ameliorative sanitation measures.

It is hoped that the papers selected for presentation in this volume will be conducive to a better appreciation of some of the air pollution investigations conducted in the USSR. As the editor of this volume I wish to thank my co-workers in the Air Pollution Section of the Institute for their valuable assistance.

M. Y. Nuttonson

January 1973

POLLUTION OF AIR WITH NOXIOUS CHEMICAL AND MECHANICAL IMPURITIES

D. A. Zil'ber, R. A. Loginova, I. N. Novikova, A. I. Olekhnovich,
M. M. Ostrovskiy, and M. D. Razumovskiy*

From "Gigiena". Pod redaktsiey Prof. G. A. Mitereva. Izdatel'stvo "Meditsina", Moskva, p. 36-46, (1970).

Because of the industrialization of the national economy, the development of various types of transportation and residential and public construction, the air of urban populated areas is considerably polluted with the waste and emissions of industrial enterprises, automobile and railroad transportation in the form of noxious vapors, gases, smoke and dust. It is justifiably assumed that atmospheric air is the sewer for various noxious impurities resulting from human vital activity and participation in the national economy. The role of the above-indicated factors, so essential in this respect, is confirmed by the fact that studies of the air of major industrial centers and rural populated areas have shown definite evidence of a heavier pollution of urban air than of the atmospheric air of small villages and of large ones.

The most common noxious gases occurring in the atmospheric air of major industrial centers are sulfur dioxide and carbon monoxide. The emission of sulfur dioxide is chiefly due to the combustion of solid fuel (anthracite coal), the sulfur content of which reaches 5%, depending on its quality. The combustion of sulfur forms sulfurous anhydride, which enters the surrounding atmosphere together with smoke. A particularly heavy pollution of air with this gas is due to the boiler houses of electric and thermoelectric power plants, and also to the boiler rooms of residential and public buildings and industrial (metallurgical, chemical, etc.) enterprises.

In the hygienic evaluation of pollution of the surrounding atmosphere with sulfurous anhydride, the properties of the latter should be taken into account, i.e., a high solubility in water and a high specific gravity. Because of these two properties, sulfur dioxide descends relatively rapidly into the lower zone of the earth's air envelope.

Descending air currents substantially promote the descent of this gas into the lower zone (inhabited zone) and the formation of a very toxic sulfuric acid fog. A fog of this kind, which formed as a result of unfavorable meteorological conditions and caused many victims, was observed in London in 1952.

Sulfurous anhydride is a chemical compound with a pronounced irritant effect on the mucous membranes of the upper respiratory tract and eyes, this being due to a rapid absorption of the gas by moist surfaces. At high concentrations, it causes acute inflammatory processes in the nasopharynx, trachea and bronchi. The victims complain of a painful dry cough, hoarseness, difficult breathing, etc. The chief symptoms of the effect are: abundant lachrymation, sharp pain in attempts to close the eyelids, conjunctivitis. In chronic poisoning, the most characteristic symptoms are pulmonary emphysema, gastrointestinal disturbances, and impairment of metabolism. It should be noted that cases of serious poisoning can occur only under industrial conditions, since in atmospheric air the content of sulfur dioxide is usually negligible.

---

* The book was written by a group of authors from the Department of General Hygiene of the I. N. Sechenov Medical Institute (Docent R. A. Loginova, Candidate of Medical Sciences I. M. Novikova) in collaboration with the staff of the General Hygiene Department of the Leningrad Chemico-Pharmaceutical Institute (Prof. D. A. Zil'ber [deceased], Candidate of Medical Sciences A. I. Olekhnovich, Candidate of Medical Sciences M. M. Ostrovskiy, and Candidate of Medical Sciences M. D. Razumovskiy).

The presence of sulfur dioxide in the air of populated areas is inadmissible not only because of its adverse effects on the health of the population. A considerable danger of sulfur dioxide to many life forms in nature also has been demonstrated. In particular, it has a harmful effect on vegetation, disrupting the processes of photosynthesis in conifers and deciduous tree species and causing the death of wild plants and grasses.

In connection with the extensive development of motor transport, the problem of atmospheric air purity has become particularly urgent. This is because motor transport is a source of pollution of atmospheric air with a very dangerous component of exhaust gases, carbon monoxide. It is observed in the streets of populated areas in the presence of heavy motor traffic in the vicinity of various industrial enterprises (metallurgical and chemical plants, railroad shops, large motorcar fleets, etc.). In the exhaust gases of automobiles, the carbon monoxide concentration ranges from 1 to 13.5% (depending on the system of the engine, its operation and conditions, the type of fuel); in the smoke of locomotive fire boxes, from 2 to 3.6%; in tobacco smoke, 0.5-1%, and in the smoke of residential furnaces, up to 1.5%. The heaviest pollution of atmospheric air takes place during fires and explosions. Sanitary-hygienic studies have shown that on the main streets of cities and towns, particularly at points of largest accumulation of automobile traffic, the average carbon monoxide concentrations do not exceed 30 mg/m^3, and the maximum ones, around 90 mg/m^3. It is quite obvious that carbon monoxide in these concentrations can cause neither acute poisoning nor distinct pathological changes. However, prolonged inhalation of street air polluted with carbon monoxide may give rise to symptoms of intoxication: headache, throbbing in the temples, and other symptoms of a general character (according to the data of a survey conducted on a large group of traffic policemen).

It is necessary to consider separately the accumulations of carbon monoxide that are dangerous to health in enclosed areas. Such a situation may take place in poorly ventilated garages, in residential and public buildings with stove heating when the stovepipes have been prematurely closed, when the rules governing the use of equipment operating on kitchen gas have been grossly violated, etc. It should always be kept in mind that the symptoms of carbon monoxide poisoning appear gradually, so that a person can easily overcome the initial health disturbances. However, the latter are soon followed by muscular weakness, as a result of which the victim finds it extremely difficult to leave the room in which the poisoning has taken place on his own. This fact accounts for the grave results of carbon monoxide poisoning in some cases, under either everyday living conditions or industrial conditions.

In addition to the indicated toxic impurities, outdoor air may become polluted with emissions containing nitrogen oxides, chlorine, hydrogen chloride, hydrogen sulfide, hydrocarbons, etc. In the great majority of cases, these noxious vapors and gaseous impurities are found in atmospheric air near industrial enterprises, and the character of the impurities depends on the nature of the production. For example, nitrogen oxides can be found around plants producing nitric acid, chlorine in the vicinity of chlorine and bleaching powder plants, carbon disulfide in the vicinity of rayon plants, hydrogen sulfide in areas of petroleum production, etc.

Another variety of atmospheric pollutants are mechanical impurities - dust and smoke. From a physicochemical standpoint, they constitute a system of aerosols containing a dispersed phase -- particles in the solid or liquid state suspended in air -- and the dispersion medium -- atmospheric air. Aerosols possess a very high physicochemical activity due to their extensive adsorbing surface. The latter is directly proportional to the fineness of the substance or its dispersity. It has been established that the greater the dispersity of aerosols, the higher their specific surface. An increase in specific surface leads in turn to a sharp increase of the contact between the dispersed phase and the surrounding medium, i.e., to an increase in the physiological activity of aerosols.

Each particle hovering in air is acted upon by two forces -- the force of gravity, as a result of which it tries to settle, and the frictional force of the medium, which prevents its settling. Studies have established that if the force of gravity predominates over the drag, the particles settle out of the air relatively quickly and with increasing velocity. It follows that the great majority of particles cause only a temporary pollution of the air medium. At the same time, in moving air and in the presence of convection currents, particles whose size does not exceed 10 μ practically fail to settle. Particles less than 0.1 μ in size are constantly in a hovering state because of Brownian molecular motion (impacts of gas molecules). In accordance with the above, at the present time, dust is considered to be a dispersed phase of an aerosol with particles larger than 0.1 μ in size, and smoke, with a particle size 0.1 μ or smaller.

The chief source of pollution of air with dust and smoke are practically the same as with vapor and gaseous impurities. They are the emissions of industrial enterprises, electric and thermoelectric power plants, boiler rooms of residential and public buildings, and railroad transportation. The formation of soil dust considerably promotes the imperfection of street coatings.

A special role in the pollution of atmospheric air with noxious impurities is played by smoke. The latter consists of a mixture of air with solid and gaseous products of fuel undergoing combustion. The largest amounts of dust, with high contents of soot, carbon black and carbon monoxide, are evolved primarily in cases where there is an incomplete combustion of fuel as a result of an insufficient supply of oxygen to the source of combustion. However, even when the fuel combustion is complete, as in the case of boiler rooms of large industrial enterprises and electric and thermoelectric power plants, particularly when low-grade fuel is used, atmospheric air is polluted with fly ash, particles of unburned coal and sulfurous anhydride discharged together with the flue gases. The degree of pollution of atmospheric air of populated areas by these impurities depends, on the one hand, on the content in the fuel of ballast substances -- ash and sulfur, whose quantity is determined by the type of fuel, and on the other hand, by the structure of the furnace. For example, the combustion of coal dust discharges into the air 75-80% of the ash contained in the fuel, and when lump coal is used, only 25-30%. It has been established that the combustion of 1 ton of anthracite coal may discharge into atmospheric air about 120 kg of ash in the form of smoke. It should be added that along with the flue gases, particles of the coal itself are carried into the air. In contrast to anthracite coal, some forms of liquid fuel (particularly mazut) contain a minimum amount of ballast substances, so that no discharge of dust particles takes place.

If the concentrations of atmospheric pollutants are regularly determined on the plant site itself and at various distances from it, one can establish that these pollutants spread over many thousands of meters depending on the direction and velocity of the wind, character of the polluting substances, and humidity of the air. Studies have shown that the highest concentrations are observed on the plant site near the object emitting the pollution (shop, plant complex, production unit, etc.). The content of noxious impurities decreases with increasing distance from the pollution source, but the zone of their propagation reaches 5-6 km, and in some cases more.

Of major hygienic importance is the zonal distribution of atmospheric pollutants. To this day cases are observed in which atmospheric pollutants (primarily in areas with old buildings and planning) reach residential districts, polluting urban air reservoirs. Such atmospheric pollutants have an adverse effect on the health of the population, on the surrounding vegetation, and on the microclimate.

The influence on the health of the population is determined primarily by the fact that a constant exposure to polluted air is a factor predisposing to the appearance of various diseases of the respiratory system. In persons living in areas where the atmospheric air is constantly polluted with noxious vapors, gases or dust, the content of which never reaches toxic values, inflammations of the respiratory tract and nasopharynx still occur more frequently than among the population of "clean" areas. Ash and dust particles discharged with the flue gases cause not only an irritation of the mucous membranes, but also chronic inflammatory processes of the conjunctive. As was shown by studies made in recent years, prolonged inhalation of small amounts of toxic substances makes people feel worse, injures their health, decreases their working capacity, and has an adverse effect on the resistance of the organism to infectious diseases (especially in children).

All of the above concerning the effect of atmospheric pollutants on people, the animal world, and vegetation can be confirmed by several examples. It is known that some petroleum refineries and plants in the U.S.A. use high-sulfur petroleum as fuel. In one of the states where such plants are located, a broad medical survey of the population was conducted. Results of the survey showed that persons who complained of unpleasant odors had various pathological symptoms of a general character: headache, insomnia, difficult breathing, irritation of the upper respiratory tract. All these symptoms arose periodically in connection with the appearance of noxious impurities in the atmosphere. All of the symptoms described frequently led to an increased fatigue, a reduction of working capacity and functional disturbances of the nervous system. In a survey of the status of the health of 1322 young schoolchildren (Institute of General and Communal Hygiene, Academy of Medical Sciences, USSR) residing in the area of discharges of a high-capacity central heating-and-power plant, many essentially healthy children showed incipient fibrous changes in the lungs, and the children themselves complained of frequent headache, general weakness, irritation of the mucous membranes of the eyes, rapid fatigability, etc. Similar complaints were voiced by the population living in the area of a viscose plant in Belorussia, where pollution of atmospheric air with carbon disulfide and sulfurous anhydride took place.

The adverse effect of atmospheric pollutants on cattle can be estimated from the following fact recorded in the vicinity of one of the West German plants: a large herd of cattle belonging to the population of the plant settlement was completely annihilated. In addition, the population of the settlement noted a marked decrease in the number of bees, the death of certain species of wild animals, and damage to the vegetation even at a distance of 5 km from the plant. An unquestionable role in this event was played by the pollution of air with sulfurous anhydride and dust containing arsenic, ferric oxide, antimony, etc. There are numerous reports of the death of crowns and destruction of foliage on trees in the vicinity of chemical plants. The noxious influence of atmospheric pollutants also includes a deterioration of the housing and living conditions of the population: as a result of the unpleasant odors, many are deprived of the opportunity of opening the windows and ventilating their dwellings, and there is contamination with soot and carbon black of the external finish of buildings. Some industrial discharges have a destructive effect on the metal roofs of residential and public buildings.

Particular attention should be given to the fact that certain carcinogenic products are found in the composition of coal tar and dust. These substances condense on the particles of ash and soot reaching atmospheric air in the form of flue gases. This must be remembered, since certain types of fuel containing carcinogenic compounds form very large amounts of flue gases as a result of inadequate combustion. Sources of such atmospheric pollution in cities may also be asphalt-concrete, roofing, Ruberoid and shale-distilling plants. Comparative data on the spread of lung cancer among inhabitants of various populated areas have shown that this disease more frequently affects persons who reside for a long time in industrial cities where the air reservoir is characterized by the presence of large amounts of atmospheric pollutants.

Finally, the dust and smoke in the air reservoir of populated areas decrease the transparency of the atmosphere, causing a reduction of the total illumination and, what is particularly important, cause a considerable attenuation of the intensity of the ultraviolet part of solar radiation. Measurements of illumination with scattered light in the industrial area of Moscow and at a distance of 8-10 km from the center have established that within the city limits, the illumination is 40-50% less. In comparison with the environs, the intensity of solar radiation in Paris is 25-30% lower, in Baltimore, 50%, and in Berlin, 67%.

Measures designed to protect the atmospheric air of populated areas from pollution by chemical and mechanical impurities. The struggle for atmospheric air purity has now become the most important problem of Soviet hygiene. This problem is being solved by preventive legislative measures: planning, technological and sanitary-technical measures. The decision of the Council of Ministers of the USSR "On measures of control of atmospheric pollution and improvement of sanitary-hygienic conditions of populated areas" (1949) forbids ministries and services from putting enterprises and shops into operation without first providing them with an efficient system of purification of industrial emissions.

Under the law "On the Protection of Nature in the RSFSR", adopted in 1960, atmospheric air is treated as a component of nature, as a natural resource subject to protection. The law charges executive committees, agencies, institutions and other organizations with implementing a set of measures for preventing the pollution of atmospheric air: introduction of rational technology excluding the penetration of noxious waste into the atmosphere, use of efficient purification and recovery equipment, etc. The law requires a strict observance of hygienic standards of atmospheric purity. One of the most essential measures taken by the Soviet government in this direction is the regulation of the maximum permissible concentrations of chemical and mechanical impurities for the atmospheric air of populated areas, i.e., such contents for which it is impossible to have either a direct action of these impurities on the human organism, living conditions, working capacity and subjective health, or an indirect influence on health caused by a substantial loss of biologically valuable ultraviolet sunlight, a reduction of the transparency of the atmosphere, a deleterious effect on vegetation, etc. In other words, maximum permissible concentrations are amounts of atmospheric pollutants that cannot cause any harm to the health of the population. The values of these concentrations are established by long-term experiments on animals, and the permissible value is a concentration that after many days of exposure causes no appreciable functional changes or biochemical reactions. The levels of the maximum permissible concentrations should lie below the values at which not only disturbances of reactivity, but even defensive or adaptive reactions are observed.

The sanitary legislation of the USSR has adopted two values of concentrations for the maximum permissible levels of atmospheric pollutants: the highest one-time and mean daily concentrations. The former concentration represents the standard to which the highest concentration of the pollutant observed in the atmosphere must be compared; the latter is the arithmetic mean of values obtained in the course of a day by repeated measurements recorded graphically, continuously or periodically. By comparing the values of the pollutants, obtained by analyzing the air, with the regulated standards, one can quantitatively characterize the content of noxious impurities, then evaluate the purity of atmospheric air from a sanitary point of view.

Table 1 below gives the maximum permissible concentrations of certain noxious impurities in the atmospheric air of populated areas (excerpted from SN 245-63).

The presence of regulated maximum permissible concentrations of atmospheric pollutants enables sanitary inspection agencies to recommend to enterprises the requirements for implementing technological and sanitary engineering measures in conformity with the sanitary legislation. The purpose of these requirements is to protect the urban air reservoirs from industrial discharges and to limit the content of noxious impurities in atmospheric air. In ratifying projects for new construction of enterprises, electric power plants and other facilities, the sanitary agencies have the right of dissent if the documentation considered fails to stipulate installations for purifying industrial discharges. Such installations include various dust- and gas-purification systems which remove volatile aerosols and noxious gaseous impurities from the flue gases. Unfortunately, modern engineering does not provide for a complete removal of these substances from flue gases. For this reason, even in operating the most efficient purification equipment, it is necessary to provide for the installation of sufficiently high plant stacks. Thanks to the latter, smoke and ash are discharged into the zone of air currents moving rapidly above the earth's surface.

Of considerable hygienic importance is the use as fuel of coal grades with the lowest ash content, and the achievement of conditions of complete fuel combustion. An important role in air pollution control is that of gasification and electrification of industrial processes, extensive use of gas and

Table 1

Maximum Permissible Concentrations of Certain Noxious Impurities in Atmospheric Air

Noxious Substance	Maximum Permissible Concentration, mg/m^3	
	Highest One-time	Mean Daily
1. Acrolein	0,30	0,10
2. Amyl acetate	0,1	0,1
3. Acetone	0,35	0,35
4. Benzene	2,40	0,80
5. Butyl acetate	0,1	0,1
6. Vinyl acetate	0,2	0,2
7. Dichloroethane	3,0	1,0
8. Methanol	1,5	0,5
9. Methyl acetate	0,07	0,07
10. Arsenic (inorganic compounds except arsine)	—	0,003
11. Carbon monoxide	6,0	1,0
12. Nitric oxide	0,3	0,1
13. Nontoxic dust	0,5	0,15
14. Metallic mercury	—	0,0003
15. Sulfurous anhydride	0,5	0,15
16. Hydrogen sulfide	0,008	0,008
17. Carbon disulfide	0,03	0,01
18. Soot (carbon black)	0,15	0,05
19. Formaldehyde	0,035	0,012
20. Phenol	0,01	0,01
21. Fluorine compounds	0,03	0,01
22. Chlorine	0,1	0,03
23. Hydrogen chloride	0,05	0,015
24. Ethyl acetate	0,1	0,1

electricity by consumers, introduction of central heating in towns, etc. In all industrial plants, conditions should be created for preventing the pollution of air with noxious impurities by perfecting the technology, sealing the equipment, etc. In many cases, it is possible to recover the effluent vapors, i.e., partly recycle valuable materials by removing them from the mixture with air by means of absorbers, condensation of vapors, or distillation. Both the recovery and the utilization of production waste aimed at the production of valuable materials are very economical and are of considerable hygienic importance.

Finally, the sanitary legislation of the USSR specifies planned measures aimed at the protection of atmospheric air of industrial towns from chemical and mechanical pollutants. These measures consist in the fact that in planning industrial enterprises, sanitary-protective zones representing minimal distances (gaps) between the industrial facilities and residential areas of the town are regulated. Sanitary-protective zones promote the dispersal of industrial emissions and thus reduce the content of noxious impurities (with increasing distance from the source of atmospheric pollution) to permissible values. The width of the protective zone is established as a function of the toxicity of the discharged impurities and of the conditions of the technological process (from 50 to 1000 m). At the same time, it is necessary to consider the wind rose and arrange the residential areas on the windward side in relation to the enterprises. For plants manufacturing synthetic drugs, the width of the protective zone should be no less than 1000 m, and for plants producing alkaloids, galena preparations, organic preparations, pharmaceutical potassium salts, etc., no less than 100 m.

In controlling street-dust air pollution, it is necessary to make use of street sprinkling, mechanized cleaning, improved coatings, planting of greenery, etc.

PROTECTION OF THE ENVIRONMENT FROM POLLUTION

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The protection of the environment from pollution is an extremely broad, multifaceted and complex problem, both scientifically and in practice. The concept of the environment itself includes both social and natural conditions. Thus, a purely medical hygienic treatment of the subject is intimately related to problems of nature as a whole.

As far back as 1919, the prophylactic character of Soviet health protection was defined, and the key measures aimed at the improvement of the environment included the need for sanitary protection of water and atmospheric air. Among the many decisions by the party and government concerning steps toward elimination of environmental pollution, a major importance was assumed by the decision of the Central Committee of the CPSU and Soviet Ministers of the USSR on "Steps Toward Further Improvement of Medical Services and Protection of Public Health in the USSR" of 14 January 1960. The same year, a law was enacted concerning the protection of nature in the RSFSR, article 12 of which specifically mentions the sanitary protection of water sources and atmospheric air.

Thus, our legislation specified a natural, organic bond between sanitary objectives toward improvement of the environment and objectives of nature preservation as a whole.

Nearly all countries in the world are faced with the problem of environmental pollution. Chief cause of the latter is an immutable tendency toward a rapid industrial development, which is accompanied by a no less rapid urban development. In the last 100 years, the population of the globe has doubled, whereas the urban population has quintupled, so that the amount of consumer and industrial waste waters has increased sharply. Even more acute are the manifestations of the effects of industrialization and urbanization on the pollution of atmospheric air, since it is practically impossible to protect the inhabitants of towns and industrial areas from a continuous and prolonged influence of atmospheric pollution. Authentic disasters around industrial towns, particularly during periods of anticyclonic weather, fog and atmospheric inversions have been recorded involving cases of massive intoxication.

The committee of experts of the World Health Organization in a technical report published in 1966 notes that in a world which is becoming urbanized and industrialized at the current rates, it will be impossible to preserve the environment in its natural state. The law should be aimed precisely at the control of pollution. Soviet water sanitation legislation prohibits the drainage of waste waters into water reservoirs and the discharge of pollutants into atmospheric air, in accordance with the "Rules of Protection of Surface Waters from Pollution by Waste Waters" (1961). The drainage of the following waste waters into water reservoirs is prohibited:

1) waters that, when the technical and economic conditions are maintained, can be eliminated by an appropriate technology with the maximum utilization of the water supply in the return system, use of irrigation of fields with the maintenance of necessary sanitary requirements, etc.;

2) waters containing valuable waste that can be utilized by the plant concerned or other plants;

3) waters containing industrial waste, reagents, intermediate products and target products in amounts exceeding the norms of allowed technological losses established for the corresponding production by a supervising agency.

However, depending on the nature of the production process and characteristics of the composition of industrial waste waters, and also the technical-economic conditions, these requirements cannot by any means be always satisfied. It thus becomes necessary to drain the waste waters into water reservoirs or to discharge industrial pollutants into atmospheric air. The indicated rules of protection of surface waters from pollution with waste waters state that "when it becomes necessary to drain the waste waters because of the inadequacy of the measures indicated in paragraph 7, or when it is impossible to fulfill them for demonstrated technical-economic reasons, drainage of the waste waters into water reservoirs can be permitted only if the requirements and standards set forth in the present regulations are observed."

An achievement of our science and practical experience is the determination of the purity criterion and, conversely, of the concept of pollution of the environment - atmospheric air and water reservoirs. The concept of pollution is understood to mean the following: surface waters are considered polluted if their composition or properties have changed under the direct or indirect influence of industrial activity and everyday living conditions of the population, and they have become unsuitable for one or several types of water use. The onset of pollution of the environment is determined from purity standards, i.e., such values of the indices of composition and properties that express the interests and requirements of the population in regard to the quality of water and atmospheric air.

Accordingly, the hygienic criterion of harmfulness of pollutants reaching the environment is a degree of its pollution which has an adverse effect on the health of the population. A hygienic standard is an index of the composition and properties of the environment which excludes an adverse influence on health and ensures favorable living conditions for the population. Thus, a scientifically validated definition of the concept of environmental pollution, together with a practical application of hygienic standards of the composition of the environment, have imparted the necessary concreteness to the practice of sanitary control.

Hygienic standards have begun to serve as the fundamental guidelines for those who are charged with fulfilling the requirements of sanitation agencies and those charged with their implementation. This role of standards is also predetermined by their inclusion in sanitary legislation, which is undergoing a major development with each passing year. As a result of the many years of activity of many sanitary-hygienic institutes in this country, standards have been developed for the most common industrial pollutants reaching the water reservoirs (for approximately 200 substances). For atmospheric pollutants of the air of populated areas, standards have been approved for approximately 70 substances.

Since the standards reflect the interests of public health, which is affected only by water from water sources and by atmospheric air, the standards pertain only to the water of reservoirs at points where the water is used, and also to atmospheric air on the territory of these populated areas. The standards are worked out from a hygienic standpoint and are validated mainly by lengthy experimental studies. The latter involve all modern physiological, pathophysiological, sanitary-toxicological, biochemical, histological and histochemical studies and also the usual sanitary-chemical and sanitary-bacteriological investigations.

Such a comprehensive approach to the study of noxious substances entering the water reservoirs and atmospheric air makes it possible to detect a danger, i.e., the character of harmful effects of industrial pollutants, and at the same time, by testing a series of doses or concentrations, the level of their harmlessness. The observed harmless concentrations or doses of industrial pollutants are used as the basis for the standards. Hygienic standards are designed for protection of the environment in the interests of public health, but in addition, in their overwhelming majority, they play a wider role in the protection of nature from pollution. For example 1/5 of all the standards for sanitary protection of water reservoirs are determined from general sanitary indications of harmfulness, i.e., with the condition of preservation of the normal course of the processes in which the pollution is spontaneously removed from the water reservoirs. At the same time, 4/5 of the adopted standards for water reservoirs are established on the basis of sanitary-toxicological and organoleptic indices of harmfulness and are thus considerably lower than those in the presence of which the natural processes of self-purification of water reservoirs take place.

In recent years, the conditions of the joint, combined effect of several noxious substances on the organism have also been studied, this being frequently the case in the pollution of water reservoirs and atmospheric air, particularly in industrial areas, in the presence of many industrial enterprises whose processes have different effects. Soviet hygienic science was the first to detect and establish the principle of simple summation of the action of these substances on the organism. This makes it necessary to decrease the maximum permissible concentration of each individual noxious substance by as many times as there are such substances participating in the complex. This principle was also adopted in our sanitary legislation; the sanitary requirements for protection of the environment from pollution have become more substantiated and rigorous.

In the development of scientific bases and principles of Soviet sanitary legislation in the area of protection of water and atmospheric air, Soviet hygienic science and sanitary practice have far outdistanced everything that has been done abroad. Nor was the international recognition that they received accidental. This legislation formed the basis of official agreement between eight socialist countries' members of the Council of Economic Mutual Assistance (CEMA).

Particular attention should be given to the implementation of requirements of sanitary legislation regarding the protection of the water and air of populated areas. Improvement of sanitary protection of air is favored by measures involving a general improvement of the living conditions of the population, i.e., gasification of apartments and central heating in towns and industrial centers, resulting in a substantial decrease in the amount of discharges into atmospheric air.

It is necessary to intensify the work of all scientific research institutions and planning agencies that are responsible for protecting the environment from pollution. A central organizing agency is needed that would supervise the practical activity in this area and provide for appropriate financing of all-important measures.

FUNDAMENTAL PROBLEMS OF SANITARY SCIENCE AND PRACTICE IN CONNECTION WITH THE DEVELOPMENT OF INDUSTRY IN THE UKRAINIAN SSR AND WAYS OF SOLVING THEM

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With great enthusiasm, the Soviet people are implementing the grandiose outlines of the program of the CPSS developed by the 23rd Party Congress and successfully solving the chief economic problem of creating a material and technological base for Communism.

The implementation of the formulated problem is tied up with a vigorous growth of industry in this country, giving rise to a number of sanitary questions demanding a concrete solution both on the part of practical health protection agencies and on the part of sanitary science.

In the Ukrainian SSR, all the prerequisites exist for a successful solution of the chief problem dictated by life, i. e., the improvement of sanitation of working and living conditions, which is possible only when a high principle is pursued, namely, everything in the name of man and for the good of man a principle being pursued by the Communist Party in this country.

An extensive network of sanitary epidemiological institutions with well-equipped laboratories has been created in the Ukrainian Republic, and there are 10 scientific research institutes of sanitary-hygienic character. About 7000 physicians and scientists are working in sanitary epidemiological institutions, scientific research institutes, and hygiene departments of medical institutes.

In the final solution of the problem of amelioration of the environment in the presence of a rapidly developing industry, a prime importance is assumed by a number of major questions involving the improvement of the layout of populated areas, protection of atmospheric air, soil and open water reservoirs, and also the improvement of working conditions for the workers....*

In order to improve the sanitary conditions of the air reservoir, a number of measures of both organizational and technical character are being carried out in the Republic.

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* Editor's note: Ellipsis points indicate the omission of material not relevant to the specific subject of air pollution.

Considerable appropriations are allocated each year to the implementation of measures aimed at the protection of atmospheric air. In the last few years, 200 dust and gas purification installations have been constructed, and hundreds of industrial enterprises and heating boilers have been converted to gas operation.

It was shown experimentally that a properly organized dust collection may substantially reduce the discharge of industrial dust into atmospheric air. Thus, measures taken at the cement plant in Dneprodzerzhinsk made it possible to reduce the cement dust loss from 300 tons per day in 1948 to 16.5 tons per day in 1966.

It should be noted that a successful implementation of measures aimed at sanitary protection of atmospheric air also has a positive effect on the economic indices of the enterprises. At the Krivoy Rog southern ore-dressing complex, a special service numbering 130 persons has been established for supervision, heavy and maintenance repairs, and the determination of the efficiency of ventilation systems and installations for purifying discharges into the atmosphere. Measures taken at the complex for the purpose of increasing the efficiency of operation of dust-collecting units and also a fixed daily competent control of their operation resulted in a decrease of dust loss at the complex from 100 tons per day in 1962 to 20 tons per day in 1966. From the crushing, dressing and sintering departments the collected dust is recycled into the process as a pulp. In particular, at the sintering plants, the amount of dust recovered amounts to 480-570 tons per year, with an iron content of up to 51%. The economic effect of this measure amounts to 1710 thousand rubles per year. At the Kramatorskiy metallurgical plant im. Kuybyshev, a gas purification unit for a blast furnace producing ferromanganese pig iron was constructed, eliminating a discharge of 25,000 m^3 of blast furnace gas per hour; a bleeder was constructed for burning up the excess blast furnace gas, and the consumption of solid fuel at the electric blower plant was reduced tenfold.

Thus, wherever they are fully implemented, measures aimed at protecting the air result in a considerable reduction in the pollution of the air reservoir. However, the question of protection of atmospheric air still remains urgent and its solution should be given considerable attention.

It is necessary to turn the attention of technological, planning and scientific research institutes to the development of methods for recovering chemical substances from discharges into the atmosphere and utilizing them. Thus, far, there has been no effective method of trapping sulfurous anhydride from the flue gases of electric power plants, hydrogen sulfide from the ventilation discharges of synthetic fiber plants, nitrogen oxides from nitrogen fertilizer plants, etc. The air of a number of industrial towns and workers' settlements continues to be polluted with the discharges of industrial enterprises and exhaust gases of automobiles.

For many years, in planning new industrial facilities, the planning agencies did not consider the pollution of air by the existing industry. Calculations to determine the discharges of new plants into the atmosphere did not take into account the existing total concentration of the substances polluting the air. For this reason, at the present time, further development of industry in individual industrial towns is envisaged as a function of the decrease in the general background of atmospheric pollutants.

Measures aimed at protecting the atmospheric air should be initiated during the very first stage of construction, i. e., in the blueprints of the enterprise. On the recommendation of agencies of the sanitary service, the State Committee on Construction of the Ukrainian SSR issued a decree ordering all the planning agencies to work out measures for the protection of atmospheric air in the projects of general plans for urban development.

Thus, the negative influence of rapidly developing industry on the external environment - air and water reservoirs - can be reduced and even completely eliminated by carrying out certain prompt and radical measures. In the future, the efforts of scientists and technicians should be directed at finding the most effective methods of purification and utilization of substances in waste waters and discharges into the atmosphere that are useful to the national economy.

The rapid development of the chemical industry and the broad scale of introduction of chemical products into various sectors of the national economy and every day life have made the problem of hygienic and toxicological evaluation of new chemical preparations one of the most pressing ones. Moreover, the wide use of toxic substances in agriculture and forestry, and in railroad and water transportation, demanded from the sanitary epidemiological service the introduction of effective control measures designed to protect the environment from pollution with pesticides.

Much has already been done to solve this major economic problem. Thus, laboratories have been created at regional sanitary-epidemiological stations in order to control the accumulation of toxic chemicals in agricultural products and objects of the external environment. In 1960, the content of such chemicals was being studied by six laboratories; in 1965 by 242, and in 1968, by 320. The number of studies also increased considerably: in 1960, 507 analyses of food products, feeds and objects in the external environment were carried out; in 1968, 58,772 studies of food products and of 4,128 objects of the external environment were made....

LOCAL INDUSTRIAL POLLUTION OF ATMOSPHERIC AIR

K. N. Blagosklonov, A. A. Inozemtsev, and V. N. Tikhomirov

From "Okhrana Prirody", K. N. Blagosklonov, A. A. Inozemtsev, V. N. Tikhomirov. Pod redakatsiey Prof. N. A. Gladkova. Izdatel'stvo "Vysshaya Shkola", Moskva, p. 88-89, (1967).

Protection of air - a sanitary and economic problem. The problem of control of noxious aerosols is one of the most pressing in the 20th century. We live our entire life on the botoom of a great ocean of aerosols. There is no such thing as clean air in the world: with each breath we inhale countless fine particles suspended in the air (Petryanov, 1962).

Smoke, noxious gases and other atmospheric pollutants are the source of many inconveniences and discomforts, chief of which is the deterioration of human health. Polluted air is harmful to health, and that is why the problem of atmospheric air purity is first and foremost a sanitary one, and is urgent throughout the world. Scientific congresses are being convened, a special literature is being published, associations are being organized, and thousands of doctors, chemists, physicists, economists, and engineers are working to solve the problem of air purity, primarily in urban areas.

According to the Program of the CPSU, this country in the near future will see the implementation of broad measures in municipal construction and environmentally oriented planning of all towns and workers' settlements, which require the"implementation of a system of steps aimed at further improvement of living conditions in towns and other populated areas, including their planting with greenery, irrigation, and a resolute struggle with the pollution of air, soil and water."*

Industry is the main source of pollution of with with noxious impurities. The utilization of the products which are now causing damage as a result of their presence in the atmosphere would yield great economy. Electric power plants alone, which burn Moscow coal, could yield up to 500 thousand tons of sulfur dioxide per year, a raw material for the chemical industry. Equipping cement plants with dust collectors would yield an additional 400 thousand tons of fine cement flour and 1.5 million tons of raw material per year.

The loss of valuable industrial waste in the U.S.A. is estimated at $1.5 billion, i.e., more than $10 per capita. This figure is larger than the amounts spent on enterprises working on prevention of atmospheric pollution (Kletter, 1961). Today it is understood by everyone that smoke constitutes evidence of squandering of valuable fuel and is an indication of low production efficiency, and that atmospheric pollution brings harm to the health of the population (Ryazanov, 1962). However, even today the negligence of plant directors, often criminal, interferes with the achievement of the necessary degree of air purity in our cities and towns.

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* Transactions of 22nd Congress of the CPSU. Gospolitizdat, 1961, p. 391.

Sources of pollution. Natural dust is always present in the atmosphere; it is indispensable to the condensation of moisture. The origin of natural dust may be threefold: mineral dust from the lithosphere, i. e., dust in the commonly accepted sense of the term; organic dust - residue of creatures that live or come into the atmosphere, and cosmic dust - residue of meteorites burned whild crossing the atmosphere.

Mineral dust may be present in the atmosphere in high concentration, for example, during the so-called "black storms," but that is due to the activity of man.

There is one more type of atmospheric pollution, the so-called "industrial dust" and gases. This may be fly ash, soot, various dispersed industrial products (cement, phosphorites), sulfur dioxide, carbon monoxide, hydrogen sulfide, carbon disulfide, chlorine, nitrogen oxides, compounds of lead, mercury, etc.

Products entering the air in the largest amounts are solid and gaseous impurities resulting from the combustion of coal.

In the absence of purification devices, almost all of the dust escapes into the air with flue gases. The scale of this process is enormous; for example, in England, 200 million tons of coal and 20 million tons of petroleum are consumed each year. The combustion of this fuel produces 2.1 million tons of smoke and soot, 5.3 million tons of sulfur dioxide, and 24 million tons of carbon monoxide. The smoke and soot contain a multitude of complex organic compounds, and some of them, as was found on experimental animals, may cause cancers (Louter, 1959).

The chief source of industrial dust are thermoelectric power plants. A steamplant of average capacity burns 2 thousand tons of coal per day, and if there is no purification, discharges around 400 tons (content of 26 railroad cars) of fly ash and 120 tons of sulfur dioxide into the air.

Second in importance as a source of atmospheric pollution with ash is railroad transport. Until just a few years ago, locomotives of the Moscow Railroad Terminal discharged into the atmosphere over 80 thousand tons of incompletely burned carbon and ash and 16-20 thousand tons of sulfur dioxide within a 30 km radius around the capital. Conversion of Moscow's railroads to electric traction has sharply reduced the smoke pollution of the suburbs. Additional substitution of diesel locomotives for shunting engines improved the situation even more.

STUDY OF ATMOSPHERIC AIR POLLUTED WITH EMISSIONS FROM A GAS PROCESSING PLANT

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In view of the high rate of development of the petroleum and petrochemical industries, the problems of protection of atmospheric air in populated areas from pollution by emissions from petroleum refineries and petrochemical plants have assumed an urgent importance.

Data characterizing the pollution of atmospheric air by emissions from gas-processing plants are lacking in the available literature. Yet the need for this type of studies is evident. The existing studies deal mainly with the aspects of the state of atmospheric air in areas where petroleum is produced.

The purpose of the present study was to investigate the sanitary state of the air reservoir in the area around a gas-processing plant. The main products of a gas-processing plant are propane, butane, isobutane, and stable gasoline; the raw material is natural gas - associated petroleum gas, which is separated after leaving the oil well. The gas is sent in gas conduits to plant purification installations and is gradually compressed in compressor sections to a pressure of 32 atmospheres. After each compression stage, the gas goes through a processing cycle involving two oil separators and three pairs of condensers followed by separation. The gas is then dried and odorized, and sent to the gas main from the final compressor section at a pressure of 45 atmospheres.

The gas is fractionated in gas-fractionating units in which the gas mixture is dissolved in an absorbent, then the various gas fractions are desorbed.

On the basis of the production process, it could have been expected that various organic substances, chiefly hydrocarbons, excape into the atmosphere. Because of the great variety of hydrocarbons discharged into the air and their different toxicities, a total determination of each of them excludes the possibility of a sanitary evaluation. Chemical methods of individual determination of hydrocarbons in atmospheric air are insufficiently advanced, and therefore certain authors (M. A. Krasovitskaya, T. S. Zaporozhets, A. S. Sobolev, 1963)* used the chromathermographic method for the individual determination of hydrocarbons; this method has become universally recognized in the last few years as the most efficient in separating and analyzing the components of complex mixtures.

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* Editor's note: A bibliography does not accompany this paper.

In the chromathermographic determination of hydrocarbons in air, we used a KhT-2M chromathermograph employed for separating gaseous mixtures in industrial laboratories. The instrument consists of a chromatographic column with stepped electrical heating, a gas analyzer where the combustion of the desorbed component takes place, and a recording instrument - an electronic potentiometer. The following conditions for carrying out the analyses were determined experimentally: voltage on the shoulder elements, 1.9 V; velocity of carrier air, 130 ml/min; pressure of carrier air at entrance to column, 1.6 atmospheres.

The samples were collected by drawing the air studied through a Y tube filled with an adsorbent (silica gel, grain size 0.5 mm), and the suction velocity of the air during the collection was 3 l/min. In summer, the tube was placed in a cooling mixture (ice with salt) during the collection, and in winter the sampling was done without a cooling mixture.

In the majority of cases, the volume of air taken for analysis was from 20 to 50 l. The instrument was placed in the path of the carrier air stream and the accumulated hydrocarbons gradually heated to 100°C. were eluted and transferred to the separatory column of the instrument.

A total of 30 samples of atmospheric air were collected by the itinerary method at distances of 100, 250, 500, 1000, 2000, 3000 and 5000 m. Simultaneously, the following meteorological factors were considered: temperature of atmospheric air, barometric pressure, humidity of air, direction and velocity of the wind. The studies showed the following saturated hydrocarbons to be present in the atmospheric air of the gas-processing plant: methane in 16% of the samples studied, ethane in 40%, propane in 81%, butane in 28%, heptane in 4%, hexane in 21%, and pentane in 96%. The gas concentration decreased with increasing distance from the source of emissions.

The table below shows the maximum one-time concentrations of the above-indicated gases, determined in atmospheric air at different distances from the pollution source.

Table.

Pollution of Atmospheric Air with Hydrocarbons in the Zone of the Gas-processing Plant.

Distance from source of pollution, m	Content of hydrocarbons, mg/m^3 (maximum one-time concentrations						
	Methane	Ethane	Propane	Butane	Pentane	Hexane	Heptane
100	90	316	116	110	21	16	—
250	90	272	131	104	48	21	—
500	27	50	22	23	26	1,6	—
1000	2,2	4,7	116	71	26	—	—
2000	—	—	18	20	64	64	0,54
3000	54	8	44	110	9,6	3,2	—
5000	—	—	—	--	8	—	—

Within a radius of 250 m from the plant, the average concentration was 65.4 mg/m^3 for propane, 38.4 mg/m^3 for butane, and 28.4 mg/m^3 for pentane.

At more distant points from the plant, the content of hydrocarbons decreases, but the pollution of the atmosphere at points located at a distance of 1000-3000 m nevertheless remains significant: propane 45 mg/m^3, butane 27.8 mg/m^3, and pentane 7 mg/m^3.

The studies showed that the concentration of hydrocarbons in atmospheric air depends on the meteorological factors. Thus, during the winter-fall period, the concentration of hydrocarbons is higher than during the spring-summer period. The maximum one-time concentrations of the individual pollutants at average wind velocities (5-6 m/sec) are: propane 131.5 mg/m^3, butane 110 mg/m^3, pentane 64 mg/m^3, heptane 5.3 mg/m^3, and hexane 21 mg/m^3.

Thus, the gas-processing plant constitutes a source of pollution of atmospheric air with a mixture of saturated hydrocarbons. The dynamics of propagation of the gases are influenced by the temperature of atmospheric air and its velocity. A substantial concentration of gases discharged by the gas-processing plant is found at distances from 100 to 3000 m, whereas at 5000 m only pentane is detected.

FERROUS METALLURGY AS A SOURCE OF ATMOSPHERIC POLLUTION

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From Ministerstvo Zdravoochraneniya RSFSR. Moskovskiy Nauchno-Issledovatel'skiy Institut Gigieny Im. F. F. Erismana. "Voprosy gigieny atmosfernogo vozdukha i planirovki naselennykh mest". Uchenye zapiski, Moskva, p. 5-9, (1968).

The sanitary protection of atmospheric air from pollution by industrial emissions has become one of the chief problems in present-day communal hygiene. The solution of these problems has attracted the interest of specialists and scientists in various professional fields.

In the last 15 years, considerable work has been done in the USSR on the biological effect and sanitary characteristics of noxious substances present in atmospheric air up to concentration levels which do not affect the organism. The maximum permissible concentrations (MPC) have now been approved for 67 substances, and the number of sanitary standards being worked on is in excess of 100 names of toxic compounds that can be discharged into the atmosphere by industrial enterprises. MPC have been adopted and are being established for a number of toxic agents for their combined action on the organism. The research data are being widely discussed in the periodical literature and also in special publications entitled "Maximum Permissible Concentrations of Atmospheric Pollutants". However, there are still few comprehensive studies describing the pollution of atmospheric air and its effect on the surrounding population, and involving a sanitary standardization of the toxic agents in accordance with the types of industrial plants or branches of industry. The chief sources of atmospheric pollution are industrial enterprises located and operated without the observance of sanitary principles. The most important of these sources may well be ferrous metallurgical plants.

For a number of years, the F. F. Erisman Institute has been studying the degree of pollution and nature of the noxious substances discharged into the atmosphere by ferrous metallurgical plants. An investigation was made on one metallurgical complex (No. 1) and on two metallurgical plants (Nos. 2 and 3). The air around the plants was studied according to seasons (spring, summer, and fall). Its content of sulfur dioxide, phenol, carbon monoxide, hydrogen sulfide, ammonia, and benzene was determined. In the present paper we shall consider only some of these indicators (phenol and sulfur dioxide). Around the metallurgical complex, the highest sulfur dioxide and phenol concentrations were found at a distance of 3 km from the points of discharge, and they were 11 times greater than the MPC of sulfur dioxide and many times greater than that of phenol.

In the area of metallurgical plant No. 2, the sulfur dioxide concentration at a distance of 500 m from the discharge was 1.6-1.2 times greater than the MPC, and in the 1000 m zone, 1.4 times greater. The phenol concentrations at a distance of 500 m from the points of discharge were 30-38 times greater than the MPC. At a distance of 1000 m, the phenol concentration was 28-30 times greater, and at 3000 m, 13-10 times greater than the sanitary norm.

Data for the area around metallurgical plant No. 3 showed that the highest concentrations of sulfur dioxide were observed in the 3 km zone, where the excess over the maximum single MPC was 5.2-3.8-fold. The phenol concentrations were 35-20 times greater than the MPC in the 1000 m zone, 18-7 times greater in the 3000 m zone, and even at a distance of 5000 m, 3.5-2 times greater.

In connection with the start of nitrogen fertilizer production based on ammonia synthesis within metallurgical plant No. 3, a second analysis of atmospheric air for the gas content was performed. An increase in the content of ammonia was observed as compared with the preceding year: 8.5-fold in the 500 m zone and 4.9-fold in the 1000 m zone.

The high concentrations of industrial pollutants in the atmosphere served as the basis for studying the influence of these discharges on the sanitary living conditions of the population and on the health of the children living in the areas surrounding these plants. Here we shall consider only certain indicators characterizing the influence of atmospheric emissions on the population living in the area of metallurgical plant No. 3 prior to the start of the nitrogen fertilizer production. To this end, the population was questioned, and a thorough medical survey was made among schoolchildren of grades 1-3 residing in two neighborhoods of the city with different degrees of atmospheric pollution with industrial discharges of the metallurgical plant. The heaviest atmospheric pollution with industrial emissions was observed in the zone from 1000 to 3000 m from the points of discharge in the plant settlement. This area was taken as the main neighborhood where one of the schools surveyed was located.

The control taken was a second neighborhood located at a distance of 5000-7000 m to the northwest of the metallurgical plant, where the other school being surveyed was located.*

In the main neighborhood, 185 adults were questioned. They all complained of the unpleasant odor of the gases from the plant, which are perceived the year round, causing difficult breathing in 58% of those questioned, headache in 65%, cough in 43%, and irritation and dust in the eyes in 63%. The discomfort increase during the early morning and evening hours, in cloudy weather, and particularly in the fall, when a strong wind is present. Many of those questioned (95-85%) mentioned a high content of dust in the air, which adversely affects the purity of air in apartments and causes clothing to become dirty; it is difficult to aerate the living quarters or to dry the laundry in the open air.

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* The medical survey of the schoolchildren was carried out by specialists from the clinical section of the Moscow Scientific Research Institute of Hygiene im. F. F. Erisman.

In the control area, 149 persons were questioned: 40% of these did not voice any complaints regarding the odor of gases, and 18% noted that sometimes when the wind was strong during the summer, there were faint odors of plant "fumes", occasionally causing cough and even nausea.

The medical survey in the main group included 504 persons, and in the control group, 492 persons. The age-sex composition and the length of residence of the children in both neighborhoods were approximately the same.

Results of the survey showed that the total number of illnesses exposed in the main group was twice as high, and illnesses of the upper respiratory tract 2.5 times as high as in the control group. Otolaryngological examinations showed a high incidence of disorders of the respiratory tract due to chronic inflammatory processes of the muccosa of the nose and pharynx, including atrophic and hypertrophic symptoms, chronic tonsillitis, and adenoid enlargement. Among schoolchildren of the main area, such illnesses were discovered in 14.3%, and in the control group in only 6.4%.

Biochemical analyses of the blood of schoolchildren in the main group showed the presence of sulfur dioxide in the blood, ranging from traces to 0.06 mg % (normally, the blood contains no sulfur dioxide). A steady exposure to atmospheric air polluted by industrial emissions from metallurgical plants has an adverse effect on the defense functions of a child's organism. This is confirmed by the amount of vitamin C in the blood and by the extent of its excretion from the organism with the urine. Thus, the excretion of vitamin C with the urine in schoolchildren of the main area was much less than in those of the control group.

Data of a neurological survey showed that children residing in the polluted neighborhood complained of headache twice as often, nausea 10 times, dizziness 5 times, and nosebleeds twice as often as the control group, etc. In this group of children there was a prevalence of functional disorders of the central nervous system, an increased fatigability and excitability, a decreased attentiveness, and a weakening of muscular strength.

Children of the main group showed a certain lag in physical development compared with schoolchildren of the control group. The main group also had more undernourished children and children with posture defects.

Hematological shifts in children residing in the area with polluted atmospheric air correlate to some extent with the above-mentioned prevalence of inflammatory illnesses of the upper respiratory tract compared with the control group.

Thus, the results of the studies show that in areas around metallurgical plants the atmospheric air is heavily polluted with industrial discharges. The composition of the latter includes highly toxic substances that have an adverse effect on the well-being of the adult population and on the health of the children residing in the zone with polluted atmospheric air.

The MPC for many toxic agents discharged into the atmosphere by ferrous metallurgical plants have already been established. Some of them have been confirmed without the determination of the maximum inactive concentrations under experimental conditions. The MPC have not yet been established for certain ingredients discharged by enterprises of this type. No studies have been made on the combined action of gaseous substances with one another and in combination with aerosols (dust). Yet the abundance of dust around metallurgical plants is sharply increasing as a result of the introduction of converter production of steel.

In the establishment of the maximum inactive concentration of sulfur dioxide in atmospheric air for conditions of a three-month chronic exposure, a concentration of this gas equal to 0.1 mg/m^3 was found to be active, as demonstrated by a number of physiological and biochemical tests. On this basis, the mean daily maximum permissible concentration for sulfur dioxide, established at 0.15 mg/m^3, should be decreased.

The laboratory of the Institute's sanitary atmospheric protection department established the highest single and mean daily maximum permissible concentrations of ammonia at the level of 0.2 mg/m^3 of air. These studies are a part of a comprehensive project of study of atmospheric pollution around the metallurgical plant, where there is an increase in the discharge of ammonia as a result of the start of operation of the nitrogen fertilizer section.

Studies of sulfur dioxide in combination with phenol established that the combined effect of this interaction is analogous to a simple summation, and the highest single concentration expressed in parts of the MPC for each of them in isolated action should not exceed unity. The mean daily MPC of sulfur dioxide and phenol present together in atmospheric air is recommended at the following levels: for sulfur dioxide 0.05 mg/m^3, and for phenol 0.005 mg/m^3.

A simple summation of the effect is also noted for phenol in combination with carbon monoxide. This is characteristic of both the reflex and resorptive effect of these substances on the human and animal organism.

In order to enhance further the sanitary measures aimed at protecting the atmosphere in areas around metallurgical plants, it is necessary to:

1. Study the biological effect and make a sanitary evaluation of the combined influence of gaseous substances with aerosols on the organism and

to establish the sanitary norms of toxic substances in atmospheric air. Determine the extent of pollution of atmospheric air and its influence on the sanitary living conditions and health of the population; take steps to eliminate the adverse effects of noxious substances specific for a given type of production.

2. Focus particular attention on the establishment of sanitary protective zones between ferrous metallurgical plants and residential areas.

3. Emphasize laboratory verification of the efficacy of measures aimed at the introduction of new methods for purifying discharges into the atmosphere and the efficacy of steps involved in modifying technological processes and increasing the industrial capacity of enterprises.

ISOLATED AND COMBINED ACTION ON THE ORGANISM OF CERTAIN TOXIC AGENTS DISCHARGED INTO THE ATMOSPHERE BY FERROUS METALLURGICAL PLANTS

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The main sources of pollution of atmospheric air are industrial enterprises whose emplacement and operation are not consistent with sanitary regulations and norms. Among the largest sources of atmospheric pollution are ferrous metallurgical plants, which pollute the air with their emissions of gaseous toxic substances and dust.

In recent years, the Moscow Scientific Research Institute of Hygiene im. F. F. Erisman has been studying the atmospheric pollution around metallurgical plants and also the influence of the pollutants on the sanitary living conditions and health of the population residing in areas around these plants. In addition, the biological effect of low concentrations of toxic substances on the organism is being studied in order to establish their highest single and mean daily maximum permissible concentrations (MPC) in atmospheric air for isolated and combined action.

The object of the present report is to present data for the validation of the mean daily MPC of certain gaseous toxic substances found in the atmospheric air around ferrous metallurgical plants.

Among the most frequent toxic substances polluting the atmospheric air around ferrous metallurgical plants are sulfur dioxide, carbon monoxide, phenol, ammonia, dust, etc.

The studies performed show that these substances are found in atmospheric air in concentrations exceeding the MPC established for them (Ye. V. Yelfimova, 1960, A. P. Makhinya, 1966; M. M. Sayfutdinov, 1966). As far as the study of the biological effect of low concentrations of toxic substances on the organism is concerned, it should be pointed out that considerable research has been done along these lines.

To date, maximum permissible concentrations have been established for a whole series of substances including phenol and carbon monoxide in atmospheric air. The emphasis on phenol and carbon monoxide is because we studied these substances in combination with other compounds escaping into the atmosphere from ferrous metallurgical enterprises.

Phenol belongs to a class of organic compounds of the aromatic series.

In its action on the organism, phenol should apparently be regarded as a poison attacking primarily the central nervous system, and also as possessing an irritant and caustic local effect (N. V. Lazarev).

Phenol escapes into the atmosphere from a whole series of industrial plants, most important of which is the by-product coke industry, which for economic reasons is currently associated with metallurgical plants.

The resorptive effect of phenol at the threshold and subthreshold concentrations of 5.0-0.1 and 0.01 mg/m^3 was studied by B. Mukhitov (1962). He found that phenol in concentrations of 5.0 and 0.1 mg/m^3 causes in animals a change of the motor chronaxy, porphyrin metabolism, cholinesterase activity, and pathomorphologic changes in internal organs. The 0.01 mg/m^3 concentration was found to be inactive. It was adopted as the mean daily MPC for phenol in atmospheric air.

One of the atmospheric pollutants from ferrous metallurgical plants is carbon monoxide. In its physical properties, carbon monoxide is a gas without color or taste, with a faint odor resembling that of garlic, a boiling point of 192°C., and a specific gravity of 0.967 relative to air.

The biological effect of low carbon monoxide concentrations in air during continuous round-the-clock exposure of experimental animals was studied by T. M. Shul'ga (1961 and 1965). The studies showed that after 2.5 months of exposure, carbon monoxide in a concentration of 2.65 mg/m^3 caused a change of the porphyrin metabolism in the experimental animals, whereas a concentration of 1.13 mg/m^3 under the same exposure conditions did not cause any changes. On the basis of these data, the established mean daily MPC for carbon monoxide in atmospheric air at a level of 1.0 mg/m^3 is considered experimentally substantiated.

The biological effect at the level of minimum active and maximum inactive concentrations of toxic substances was studied at the laboratory of the Atmospheric Protection Department of the Institute in the case of ammonia and sulfur dioxide for isolated action, and sulfur dioxide with phenol and also phenol with carbon monoxide, for combined action. The effect of the toxic substances on the organism was studied under conditions of round-the-clock chronic exposure of the experimental animals, using physiological, biochemical, toxicological and histopathological methods of investigation. Analysis of the statistical significance of the detected changes was performed by using the method of small sampling (Ye. L. Notkin, 1965). Combined data on the effect of the substances studied on the organism are listed in the table.

A major source of emission of ammonia into the atmosphere are metallurgical complexes. When by-product coke and nitrogen fertilizer plants are set up on the territory of a metallurgical complex, the amount of ammonia in

Combined Data of Experimental Studies of the Biological Action of Toxic Substances Escaping into the Atmosphere From Ferrous Metallurgical Plants

No.	Type of analysis performed	Isolated action of the substances						Combined action of the substances					
		Ammonia, mg/m³			Sulfur dioxide, mg/m³			Sulfur dioxide + phenol, mg/m³			Carbon monoxide + phenol, mg/m³		
		Group			Group			Group			Group		
		I	II	III	I	II	III	I	II	III	I	II	III
		20,0	2,0	0,2	1,5	0,5	0,1	1,5+ +0,5	0,5 + + 0,5	0,05+ +0,005	10,0+ + 2,5	3,0 + + 0,1	0,1 + +0,005
1	Weight of animals	—	—	—	—	—	—	—	—	—	+	+	—
2	Amount of erythrocytes	—	—	—	+	+	—	—	—				
3	" " hemoglobin	—	—	—	—	—	—	—	—	—	+	+	—
4	" " methemoglobin										+	+	—
5	" " carboxyhemoglobin										+	+	—
6	" " fluorescent* leucocytes	—	—	—	+	+	—	+	+	—	+	+	—
7	Cholinesterase activity	+	—	—	—	+	—	+	+	—	+	+	—
8	Nucleic acids	—	—	—	+	+	—	—	—	—			
9	Coproporphyrin metabolism	+	—	—	+	+	—	+	+	—	—	—	—
10	Excretion of vitamins with urine C*				+	+	—						
	B₁				+	+	—						
	B₂				+	+	—						
11	Ammonia content of urine	+	—	—									
12	Activity of dehydrogenases	+	+	—									
13	Latent reflex time	+	—	—	+	+	+	+	+	—	—	—	—
14	EEG				+	+	+						
15	Pathomorphologic changes	—	—	—	+	+	—	+	+	—	+	+	—
16	Oxygen consumption,												

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* Editor's note: For the Russian terms "luminescent" and "luminescence" in this paper, we have substituted "fluorescent" and "fluorescence" on the basis of the definitions of these terms.

atmospheric air increases (M. M. Sayfutdinov, 1966). In the by-product coke and nitrogen fertilizer plants, ammonia is present in the coke oven gas and in the tar waters. Atmospheric air is polluted as a result of the escape of gas in various sections of the plant through leaks in the gas lines and assemblies, as a result of pouring of liquid ammonia into tanks, and also during its distribution to customers.

In order to substantiate the mean daily MPC of ammonia in atmospheric air, aspirant M. M. Sayfutdinov (1966) subjected white rats to a round-the-clock 84-day exposure. In all, three ammonia concentrations of 20.0-2.0 and 0.2 mg/m^3 were studied. In the course of chronic exposure it was found that in animals subjected to the action of ammonia in the 20 mg/m^3 concentration, a significant acceleration of the latent time of the reflex response had occurred, recorded by the reflexogenometer instrument proposed by S. I. Gorshkov (1962). There was also observed a depression of the activity of cholinesterase and dehydrogenases in the blood of the experimental animals. The amount of coproporphyrin and ammonia excreted with the urine increased.

An ammonia concentration of 2.0 mg/m^3 under the same exposure conditions caused a depression of the activity of blood serum dehydrogenases. Ammonia in a concentration of 0.2 mg/m^3 had no appreciable effect on the organism of the experimental animals.

On the basis of these studies, the mean daily MPC of ammonia in atmospheric air was established at the level of 0.2 mg/m^3 (M. M. Sayfutdinov, 1965).

An ever-present pollutant in the atmospheric air around ferrous metallurgical enterprises is sulfur dioxide. In its physical properties, SO_2 is a colorless gas with a pungent odor; its boiling point is 10°C., and melting point, 75.5°C. The density in the liquid state is 1.43. The solubility coefficient in water is 43.26 (20°C.).

The effect of low concentrations of sulfur dioxide on the animal organism was studied by K. A. Bushtuyeva under experimental conditions (1964). In tests conducted on white rats during a 65-day continuous exposure to sulfur dioxide in concentrations of 5.0 and 10.0 mg/m^3, substantial changes were detected in the ratio of chronaxias of antagonistic muscles, an increase in the activity of whole blood cholinesterase, an increase in the amount of coproporphyrin excreted with the urine, and also histopathologic changes in the organs and tissues of experimental animals sacrificed after the exposure. Lower sulfur dioxide concentrations in isolated action under conditions of prolonged round-the-clock exposure of the experimental animals apparently have not been studied thus far, and the mean daily MPC for sulfur dioxide in atmospheric air, approved at a level of 0.15 mg/m^3, has not been experimentally validated.

In order to validate the mean daily MPC of sulfur dioxide in atmospheric air, we carried out a three-month round-the-clock exposure of white rats to three concentrations (1.5, 0.5 and 0.1 mg/m^3) in the presence of a control group of the animals.

The experimental data we obtained showed that chronic round-the-clock inhalational exposure to sulfur dioxide in concentrations of 1.5, 0.5, and 0.1 mg/m^3 causes in experimental animals an increase in the latent time of the unconditioned reflex reaction, established with the aid of the reflexogenometer instrument. In addition, these concentrations cause significant changes in the functional state of the central nervous system of the animals according to the indicator of bioelectric reactions in response to rhythmic photic stimulation of variable frequency and intensity (M. Kh. Khachaturyan and Ye. V. Yelfimova, 1966). Under the influence of sulfur dioxide in concentrations of 1.5 and 0.5 mg/m^3, an increase in the amount of erythrocytes and fluorescent leucocytes, a decrease of nucleic acids, and a change in the porphyrin metabolism and in the excretion of vitamins with the urine were established in animals of the first two groups.

Pathomorphological changes in rats sacrificed after exposure to sulfur dioxide in a concentration of 1.5 mg/m^3 show focal interstitial pneumonia in the lungs, catarrhal bronchitis, and dystrophic changes in the liver, heart, and kidneys. In the central nervous system there were reversible changes in the large neurons of the stem portion of the myelencephalon and cerebellum. Sulfur dioxide in a concentration of 0.5 mg/m^3 does not produce the above-indicated changes fully, and they are much less pronounced.

A change in the activity of whole blood cholinesterase was recorded only in animals of the second chamber, where the sulfur dioxide concentration was 0.5 mg/m^3.

The indicators of weight dynamics and blood hemoglobin content did not give any significant changes in any of the groups of experimental animals as compared with the control.

Thus, the mean daily MPC established here for sulfur dioxide in atmospheric air at the level of 0.15 mg/m^3 is a concentration acting on the organism and therefore should be revised in the direction of a decrease.

The biological effect of three different concentrations of phenol in combination with sulfur dioxide in a three-month round-the-clock exposure of experimental animals was studied by aspirant A. P. Makhinya (1965).

The substances studied were taken in the following combinations:

Group of Animals	Concentrations of Substances tested, mg/m3	
	Sulfur Dioxide	Phenol
1-st group	1,5	0,5
2-nd group	0,5	0,05
3-rd group	0,05	0,005
4-th group	Control	

It is apparent from the data of the above table that in animals of groups I and II, a decrease in the coproporphyrin excreted with the urine took place, and there was also observed a depression of the activity of blood cholinesterase, an increase in the number of fluorescent leucocytes, and a shortening of the latent time of the unconditioned reflex. Histopathologic examinations of some of the animals of group I, sacrificed after the exposure, revealed slight changes in the lungs in the form of interstitial pneumonias, degenerative changes in the kidneys, and a decrease of the glycogen function of the liver. Primary irritations of large neurons of the cortex and brain stem were found in the central nervous system. In animals of group II, the above changes were not constant and were less obvious. In rats exposed to the lowest concentrations, no histopathologic changes were observed.

On the whole, the studies established that sulfur dioxide and phenol in combination act in accordance with the principle of simple summation, and the permissible concentrations should be 0.05 mg/m^3 for sulfur dioxide and 0.005 mg/m^3 for phenol.

Phenol in combination with carbon monoxide was studied in the following concentrations:

Group of Animals	Concentrations of Substances Studied, mg/m3	
	Carbon Monoxide	Phenol
1-st group	10,0	2,5
2-nd group	3,0	0,01
3-rd group	1,0	0,005
4-th group	Control	

The data listed in the above table show that in the experimental animals of the first and second groups as compared with the controls, statistically significant changes were observed, manifested in a decrease of the amount of hemoglobin and methemoglobin, increase of carboxyhemoglobin, depression of cholinesterase activity, and decrease of the excretion of coproporphyrin with the urine.

Pathologico-anatomic autopsy of 24 white rats sacrificed immediately after the completion of exposure failed to reveal any changes in the internal organs.

Microscopic examinations showed slightly developed degenerative changes in the liver, kidneys, and heart muscle, and irritation of the mucosa of the trachea in animals of the first group (CO 10.0 mg/m^3 and phenol 2.5 mg/m^3), sacrificed after completion of the exposure.

In animals of the second group (CO 3.0 mg/m^3 and phenol 0.01 mg/m^3), the above-indicated changes were also observed, but they were much slighter and were not detected in all cases. In the third group of animals (CO 0.1 mg/m^3 and phenol 0.005 mg/m^3), no morphologic changes were found.

The results of the studies suggest that the effect of carbon monoxide in combination with phenol on the organism of experimental animals is manifested according to the principle of simple summation of the toxic substances. As far as the mean daily maximum permissible concentration for their combined presence is concerned, it should be at a level of 1.0 mg/m^3 for carbon monoxide and 0.005 mg/m^3 for phenol.

Our further studies of the biological effect of toxic substances escaping into the atmosphere from ferrous metallurgical plants are closely related to the increase in the volume of production and intensification of metallurgical processes, leading to an increase in the gas and dust emissions from steel furnaces using commercial oxygen for the acceleration of the oxidation periods of melting. An increase in the gas and dust emissions when oxygen is used in steelmaking is observed in open-hearth, Bessemer, and electric melting furnaces.

According to the data of experimental measurements on electric melting furnaces of the Novo-Lipetsk Metallurgical plant, the loss of charge amounts to about 1% of the weight of the materials loaded into the furnace. On the whole, in five hours of melting, two 100-ton electric furnaces of the plant discharge about two tons (an average of 0.4 ton/hour) of finely divided dust, 50-80% of which consists of particles less than 5 microns in size. The daily discharge of this dust without purification will amount to ten tons.

Thus, the increase in finely divided dust is a characteristic feature of modern converter steelmaking. On this basis, our future aim will be to study the combined action, on the organism and sanitary standardization, of gaseous toxic substances with finely dispersed dust discharged into the atmosphere by ferrous metallurgical enterprises.

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SANITARY ASSESSMENT OF THE STATE OF THE AIR RESERVOIR IN THE ZONE OF AN EXTRA-HIGH-CAPACITY STATE REGIONAL ELECTRIC POWER PLANT (SREPP)

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From Ministerstvo Zdravookhraneniya Ukr.SSR, L'vovskiy Nauchno-Issledovatel'skiy Institut Epidemiologii i Mikrobiologii. "Faktory vneshney sredy i ikh znachenie dlya zdorov'ya naseleniya". Respublikanskiy mezhvedomstvennyy sbornik. Vypusk 2. "Zdorov'ya", Kiev, p. 176-181, (1970).

The creation of a material and technical base of Communist society in the USSR requires a substantial enlargement of the energy resources of the country. By the end of the Five-Year Plan, the production of electric energy will amount to 1000 billion kWhr, and it will triple by the end of 1980.

The fulfillment of this major national economic objective has required the introduction of new high-capacity and extra-high-capacity power plants. The plan of development of the national economy of the USSR for 1967-1970 sets forth the necessity of building highly economical power plants of considerable capacity which will operate on local fuel.

The above indicates a growing urgency of controlling atmospheric pollution caused by discharges from extra-high-capacity steam power plants, something that would be impossible without appropriate sanitary studies.

The electric power plants of earlier capacities were justifiably classified among enterprises constituting the main sources of atmospheric pollution with fly ash and sulfur dioxide (R. A. Babayants, 1940; N. F. Dergachev, B. P. Gurinov, 1953; B. A. Ryazanov, 1954).* Many studies carried out from statistical and clinical view-points (M. S. Gol'dberg, 1957; N. Ya. Yanysheva, 1957; Ts. P. Kruglikova, V. K. Yefimova, 1958) have noted a deterioration of the sanitary living conditions and health of the juvenile and adult populations constantly exposed to atmospheric air polluted by the emissions of power plants. Foreign researchers found an epidemiological relationship between the quantity of sulfur compounds and dense particles in the ground layer of the atmosphere and the state of health and mortality of the population (J. R. Goldsmith, 1966; B. Petr, P. Schmidt, 1966; B. T. Commins, R. E. Waller, 1967; K. Horn, 1967; P. A. Kenline, C. J. Conlee, 1967).

Experimental studies made in the Soviet Union (K. A. Bushtuyeva, 1963) gave a toxicological and hygienic assessment of sulfur compounds (including sulfur dioxide) as atmospheric pollutants.

Thus, the problems of electric power plants have been dealt with in a substantial number of scientific publications. However, reports on pollution of the air reservoir with emissions of modern extra-high-capacity power plants have appeared only in the last few years (R. S. Gil'denskiol'd, M. V. Styazhkin, B. V. Rikhter, 1964; Yu. D. Dumanskiy, Ye. I. Shteynberg, Ye. N. Boldyrev et al, 1966; R. S. Gil'denskiol'd, Ya. K. Yushko, G. N. Tyurina, V. P. Dukhanova, 1968).

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*Editor's note: A bibliography does not accompany this paper.

The need for this type of study served as the basis for the present work. Investigations of the influence of emissions from an extra-high-capacity steam power plant on the state of atmospheric air were made in the zone of the Burshtyn SREPP (BSREPP), which is a part of the "Mir" ("World") international energy system.

The rated power of the BSREPP is 2.4 million kW; during the period of the study, eight units of 200 thous. kW each were put into operation. The electric power plant operates chiefly on coal of the L'vov-Volynskiy basin.

The region where the BSREPP is located is characterized by the absence of a background of gas or air pollution. The hygienic studies were compared with the production-operation parameters of the BSREPP.

The program of studies specified the determination of sulfur dioxide in atmospheric air after M. V. Alekseyeva, carbon monoxide after D. P. Senderikhina,* nitrogen dioxide after I. S. Shershevskaya and Ye. Vorontsova, hydrogen sulfide after N. G. Polezhayev, and dust by the gravimetric method by collecting the samples on FPP-15 cloth filters. The samples were collected by the itinerary method at a distance of 1-15 km from the discharge stacks of the BSREPP. A total of 446 air samples were collected by the suction method during the study.

Parallel with the sampling, a study of the meteorological conditions was made. It was noted that easterly winds predominated in the area of the BSREPP (75%); westerly winds were recorded in 25%, although it is known that westerly winds are predominant in the western regions of the Ukrainian SSR. The velocity of the air fluctuated considerably, from a complete calm to 7.5 m/sec. The air temperature was 10.7-11.0°C. during the transition period and 15.4-30.6°C. during the warm period of the year. The relative humidity was 60-80% and frequently reached 95%. The atmospheric pressure ranged from 733 to 746 mm Hg.

Results of the study of the pollution of the air reservoir by emissions from the BSREPP are shown in the table.

From the data presented it is evident that the range of progagation of individual components of the emissions from the BSREPP extends over 15 km. This was the maximum distance at which the maximum one-time concentrations of atmospheric pollutants were still determined.

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* Determined in the laboratory of the Ivan Franko oblast sanitary epidemiological station (S. M. Retu, director).

Table.

Characteristics of Pollution of Atmospheric Air with Emissions of the Burshtyn SREPP.

Distance from source of emissions, km	Concentrations, mg/m³														
	Sulfur dioxide			Hydrogen sulfide			Nitrogen dioxide			Carbon monoxide			Dust		
	Maximum one-time	Mean maximum	% of samples above MPC	Maximum one-time	Mean maximum	% of samples above MPC	Maximum one-time	Mean maximum	% of samples above MPC	Maximum one-time	Mean maximum	% of samples above MPC	Maximum one-time	Mean maximum	% of samples above MPC
Industrial site.	0,12	0,05	0	0,002	0,001	0	1,93	1,29	90	19,4	11,7	93	4,18	4,18	100
1	6,02	0,89	25	0,002	0,001	0	1,95	0,82	50	7,2	6,4	33	1,20	1,20	100
2	0,70	0,38	10	0,004	0,001	0	—	—	—	14,0	8,6	84	3,30	2,90	67
3	1,47	0,29	20	0,008	0,001	0	1,30	0,66	62	16,0	11,3	90	3,48	1,93	90
5	1,22	0,44	10	0,008	0,005	0	0,05	0,04	0	13,3	11,1	100	1,20	0,96	80
7	1,12	0,23	9	0,030	0,002	6	1,30	0,35	6	13,0	9,0	80	2,40	1,21	83
10	0,37	0,11	0	0	0	0	0,03	0,02	0	5,5	5,3	0	2,45	1,56	100
12	0,83	0,24	3	0,008	0,001	0	0,19	0,08	0	6,2	2,8	14	1,52	0,65	49
15	0,22	0,08	0	0,002	0,0004	0	0,03	0,01	0	4,0	0,6	0	0,27	0,07	0

The intensity of gas and dust pollution of atmospheric air in the 1-2 km range from the electric power plant can be described as the lowest, and this zone, as the "plume flip-over zone."

The zone of most intense and frequent fumigation and gas pollution is located in the range 3-7 km from the BSREPP. In samples collected at these distances, the largest number of cases exceeding the maximum permissible concentrations in individual ingredients were noted: 9-20% for sulfur dioxide, 80-100% for carbon monoxide, and 80-90% for dust.

The dust content at a distance of 10 km also remains above the permissible level, and the mean maximum concentration exceeds the latter by a factor of 3. The amount of gaseous impurities present in the air within this radius is at the level of the maximum permissible concentrations.

Thus, the territory with the highest pollution of the air reservoir is actually located within a radius equal to 12-28 smokestack heights, i. e., 10-40 stack heights according to calculated data.

While the present study was being carried out, certain relationships were maintained between the concentrations of atmospheric pollutants and the meteorological conditions; for example, the farthest distance of propagation of the discharge gases and dust was observed at high wind velocities (up to 7.5 m/sec).

In the zone of heaviest atmospheric pollution, i. e., at a distance of 3-7 km from the discharge stacks, there are several populated areas, including the settlement of the BSREPP. In this connection, it was of interest to study the influence on the population of the atmospheric air polluted by the discharges. To this end, a special questionnaire was submitted to 700 adults living at 7 points at distances of 1-12 km from the source of pollution. The contingents of those questioned were comparable in sex, age and length of residence in the given locality.

The population residing in the zone up to 7 km from the BSREPP noted the presence of extraneous impurities - dust, gases - in the air. Almost all of the persons questioned in populated areas located in the 1-2 km zone (96 and 95% respectively) responded affirmatively to this question. As the distance from the SREPP increases, the number of persons who noted a periodic appearance of an unpleasant odor and the settling of dust decreased, but at distances of 5 and 7 km, more than one-half of those questioned (66 and 55% reapectively) noted a periodic pollution of atmospheric air with dust and soot in the presence of winds of appropiate directions.

An unpleasant odor was noted by the population living in the 7 km range, and in the closest populated areas (1-2 km), 49-50% of those questioned characterized this odor as strong, 22-36% as weak, and 14-29% noticed no odor.

In the more distant populated areas, the proportions were different: at a distance of 3 km, 18% of those questioned noticed a strong odor, 63% did not notice; at distances of 5 and 7 km, a strong odor was noted by not more than 3 persons; it was considered weak by 41%, and went unnoticed by 53-59% of those questioned.

Complaints about air pollution were accompanied by claims that the sanitary living conditions had deteriorated (inability to ventilate the living quarters, contamination of laundry during drying outdoors).

Dust in the eyes, a sensation of burning in the eyes, cough, and rasping in the throat were most frequently mentioned by the population living in the 1-2 km range (27 and 51% respectively) and to a lesser extent in the 3 km zone (18%). Headache and dizziness were reported by 33-54% of those questioned in the 1-2 km zone and 10% in the 3 km zone.

The population of the 1-2 km zone noted the destructive influence of the emissions on vegetation, manifested in the dying of the leaves and flowers of young fruit trees.

The population residing at distances of 10 and 12 km from the SREPP noted practically no air pollution, unpleasant odor or other inconveniences attributed by the population of closer populated areas to the emissions of the power plant.

From all of the above one can conclude that installations and equipment for the purification and dilution of smoke discharges (electrostatic precipitators, smoke-stacks) do not provide for an adequate purification of the smoke discharges of the BSREPP to the permissible level. For this reason, in the zone of the electric power plant in the presence of suitable meteorological conditions, conditions that are unfavorable from a sanitary standpoint arise periodically. It is necessary to keep in mind the planned enlargement of the capacity of the BSREPP and the associated possible deterioration of the state of the air reservoir.

For the purpose of improving the sanitary conditions of the air reservoir in the zone of the BSREPP and preventing the unfavorable influence of emissions on the population, the following measures have been recommended:

1) increasing the degree of removal of fly ash from the discharge gases up to the planned level;

2) replacement of the 180-meter discharge stack by a 250 meter stack;

3) utilization of excess natural gas as an alternate fuel.

SANITARY EVALUATION OF AN EFFECTIVE METHOD OF CALCULATING THE DISPERSAL OF EMISSIONS FROM A STATE REGIONAL ELECTRIC POWER PLANT (SREPP) IN ATMOSPHERIC AIR

R. S. Gil'denskiol'd and B. V. Rikhter
(From data of comprehensive studies of 1964-1965)

From Ministerstvo Zdravoochraneniya RSFSR. Moskovskiy Nauchno-Issledovatel'skiy Institut Gigieny Im. F. F. Erismana. "Voprosy gigieny atmosfernogo vozdukha i planirovki naselennykh mest". Uchenye zapiski, Moskva, p. 16-23, (1968).

By decision of 25 July 1963, No. 83, entitled "Temporary Method for Calculating the Atmospheric Dispersal of Discharges (Ash and Sulfur Compounds) From Smokestacks of Electric Power Plants", the former State Committee for Coordination of Scientific Research in the USSR charged the personnel responsible for implementing this project with continuing the work on the improvement and better validation of this method.

According to the earlier-developed program of comprehensive studies*, the intensity and propagation of pollutants in atmospheric air were investigated in different seasons around three thermal electric power plants: in the fall of 1964 in the area of SREPP-1 (State Regional Electric Power Plant), in the winter of 1965 in the area of SREPP-2 (both stations are located in the central European part of the USSR), and in the summer of 1965 around SREPP-3 (southwestern USSR).

The location of SREPP-1 differed from the environs of the thermal electric power plant studied earlier, in 1961-63, chiefly in the predominance of forested tracts (a different characteristic of the so-called forest floor). In addition to the main fuel - coals of the Moscow Basin - SREPP-1 partially burns coals of the Donets field. Studies of atmospheric pollution under winter conditions were carried out around SREPP-2, investigated in past years. The new element was an increased power capacity of the plant to 810 MW and the start of operation of a fifth smokestack 180 m high. The studies of the air reservoir around SREPP-3 were made under markedly different climatic conditions. The location of the power plant is characterized by a gentle topography and a complete lack of any gas-polluted background of the atmosphere. After the combustion of the Donets lean coals, the stack gases were discharged through only one smokestack 180 m high. The basic industrial-technical indicators of the thermal electric power plants are listed in Table 1.

SREPP-1. In the study of the propagation of emissions in the ground layer of the atmosphere, 339 suction air samples were taken for dust (fly ash) and 2814 samples for sulfur dioxide within a 15 km radius of the smoke source. For the first time, air samples to be analyzed for dust were collected by means of an automobile aspirator under field conditions, using house vacuum cleaners of brands "Uralets" and "Raketa", supplied by an AB-4-T/230-M gasoline-powered integrated unit.

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* Cf. Scientific reports of Moscow Scientific Research Institute of Hygiene im. F. F. Erisman, "Some Aspects of Sanitary Planning and Protection of Atmospheric Air" 1966, pp. 117 and 127.

Table 1

Operating Characteristics of Thermal Electric Power Plants in the Course of the Studies

Item Designation	Measuring Units	Thermal Electric Power Plants			
		1		2	3
Power plant output	MW	450		810	200
Type, number and steam output of boiler units	t/hr	TP-240-1, 6, 240		Shikhau 6,160.67—S.P 9,230 P.K 23, 1, 640	T.P.—100, 1, 640
Fuel type		Moscow brown coal	Donets coal	Moscow brown coal	Donets coal
Calorific value Q_H^P based on data of SREPP laboratories	$\frac{\text{K cal}}{\text{kg}}$	1898— —2673	5570— —5842	2361 —2418	5944— —6443
Ash content of fuel (measurement data) A^P	%	24,49— —35,85	19,78— —23,9	27,44— —29,38	16,30— —26,0
Sulfur content (calculated) S^P	%	3,0	2,7	3,0	2,7
Efficiency of ash removers based on test data, η_{ash}	%	67—87		90—92	90—92
Temperature of flue gases, T_g	°C	137—175		129—167	64—78
Maximum consumption of fuel, B	t/hr	448,6	32,2	954,0	78,7
Number and height of smokestacks	m	3/120		4/120, 1/180	1/180
Amount of ash discharged into the atmosphere (measured) M_{ash}	t/hr	15,3—29,2		11,73— —19,34	1,40— —1,85
Amount of sulfur dioxide discharged into the atmosphere (calculated) M_{SO_2}	t/hr	27,0		57,3	4,25

The data of the study were compared with the results of a theoretical determination of the distribution of concentrations according to zones, based on the maximum values given in Table 1. The graphs (Figs. 1 and 2) show the relationship between the calculated concentrations of sulfur dioxide and dust according to zones (up to 10 km inclusive) and the actual extreme, statistically significant maximum single, and averaged maxima (frequently occurring maximum concentrations). The determination of significant zonal maximum single concentrations (nondeviating)* was made by using a series of the highest maximum concentrations consisting of a series of air samples collected under the plume daily in each zone. The composition of the series included maximum single concentrations above the average daily series of measurements (based on the largest values), only those series being considered in which the maximum was higher than or at the level of the highest single maximum permissible value. Within a radius up to 10 km from the source of emission, the number of strictly maximum single concentrations of sulfur dioxide was 359, of which 148 were processed, 136 and 48 respectively being analyzed for fly ash. In view of the low recurrence of studies and the probability that the waste piles would affect the results for sulfur content in the air samples collected in the vicinity of coal mines, the 12 and 15 km zones were excluded from the comparison.

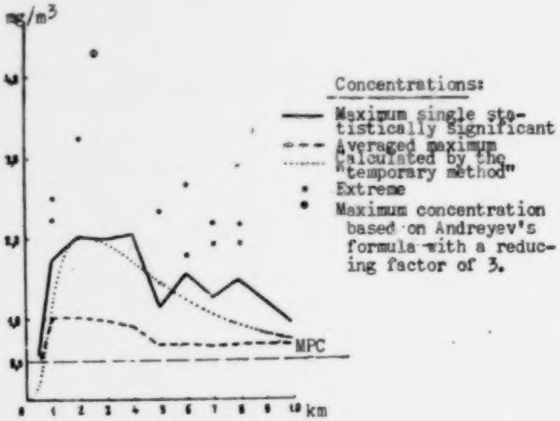

Fig. 1. Distribution of maximum concentrations of sulfur dioxide in atmospheric air in the area of SREPP-1 (actual and calculated values in mg/m³).

The patterns detected earlier in the dynamics of pollution of the atmosphere with sulfur dioxide in the area of SREPP-1 (Fig. 1) are generally confirmed. Thus, the zone where the maximum statistically significant concentrations were observed (smoke-pollution zone) covers approximately the same range from 10 to 40 smokestack heights. The distribution of actual maximum single concentrations over the zones agrees quite well with the calculated values obtained by using the "temporary method", particularly in the smoke-polluted zone. The maximum value calculated by the "temporary method", 2.03 mg/m^3, is considerably below the concentration of 4.30 mg/m^3 calculated from P. I. Andreyev's formula using a reducing factor of 3.0 (at V_0 = 3.0 m/sec). Some extreme concentrations (the largest being 3.26 mg/m^3) are substantially above the value calculated by the "temporary method", but they do not reach the level of the value calculated by Andreyev's formula. The decrease of actual maximum values in the atmosphere at remote distances from the point of discharge takes place less rapidly than indicated by the calculations. The frequently occurring maximum values (averaged maxima) in all the zones do not exceed the level of the calculated gas pollution of the ground layer of the atmosphere, calculated for the worst conditions of operation of SREPP-1.

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* Ye. L. Notkin, Statistics in Sanitary Studies, 1965, p. 151.

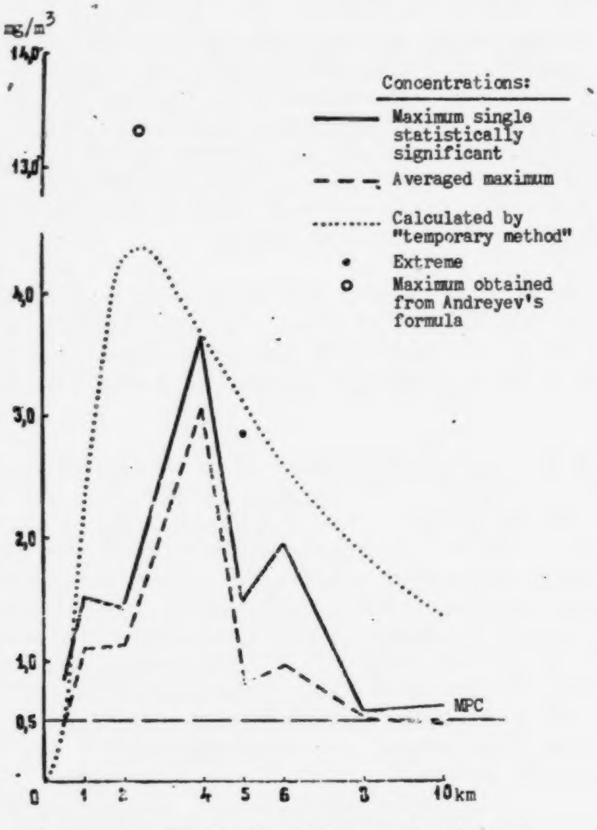

Fig. 2. Distribution of maximum concentrations of dust (fly ash) in atmospheric air in the area of SREPP-1 (actual and calculated, mg/m^3).

Comparison of calculated and measured data on the ash content of atmospheric air (Fig. 2) shows that the maximum theoretical value obtained by the "temporary method" is 4.40 mg/m^3 higher than the largest significant single concentration, equal to 3.69 mg/m^3, while the value calculated from Andreyev's formula is unaccountably high - 13.3 mg/m^3.

The discrepancy in the relationship of the calculated and actual data in studies of 1961-63 and 1964 is explained by the fact that the SREPP is surrounded by extensive forested areas. A deciduous forest, which constitutes a good natural filter, promotes a decrease in the dust content of the atmosphere. This is indirectly supported by data on the number of air samples whose dust concentrations are below the sensitivity of the method of determination. Of the total number of such samples, 70% correspond to collection points located in the forest.

SREPP-2. As follows from the data of Table 1, the fuel consumption and emission of sulfur dioxide increased over previous years (before the expansion, the maximum values were respectively 730 and 49 t/hr). The amount of ash discharged decreased in maximum values from 22.8 t/hr in 1962 to 19.3 t/hr as a result of a certain increase in the efficiency of the electrostatic precipitators (before the expansion, the average operating efficiency was 87%). Of these amounts, 3.6 t/hr of ash and 8.9 t/hr of sulfur dioxide were discharged through the new stack with H = 180 m.

The total number of air samples within a 20 km radius of SREPP-2 was 396 for dust and 2177 for sulfur dioxide. The gas samples were collected in Y-shaped absorbers placed in specially designed water heaters that prevented the absorbing solution from freezing during field studies at subzero temperatures.

The maximum single concentrations of dust in the smoke-polluted zone (2-5 km) were 1.26-2.17 mg/m^3. The largest excess over the MPC of sulfur dioxide, 2.6-fold, was observed in the 3 km zone. The smoke-polluted zone is located in the range of 1-7 km (approximately 6-40 H = 180 m). The level of maximum pollution of atmospheric air with sulfur dioxide increased as compared with the winter studies (1962 - 0.76 mg/m^3; 1963 - 1.02 mg/m^3). On the whole, the pattern of decrease in the intensity of atmospheric pollution in the area of a large-output, high, "hot" discharge source during the winter period was confirmed, and for this reason the comparison of the maximum calculated concentrations with these values is not significant. A number of steps have been planned* to reduce the generally high level of atmospheric pollution in the area of SREPP-2.

SREPP-3. The total number of air samples collected at distances up to 10 km from the emission source was 456 for dust and 2725 for sulfur dioxide. Analysis of the dust content of atmospheric air showed that the high dust content (maximum concentration 3.48 mg/m^3) is due to the presence in the air of substantial amounts of hovering vegetal and soil dust, since the period of field investigations coincided with the harvesting being done in this area under hot and dry weather conditions. For the maximum value calculated by the "temporary method", equal to 0.23 mg/m^3, the largest actual (dual) concentration was found to be 1.51 mg/m^3, whereas the background values not under the plume reached 1.2-2.7 mg/m^3. For this reason, the propagation of discharges from SREPP-3 and comparison of the measured and calculated data were analyzed on the basis of information on the zonal gas pollution of the atmosphere. Fig. 3 is a graph of the interdependence of the maximum single actual and calculated concentrations, the above-described methodical approaches being used for comparing the series of maximum concentrations. The treatment did not include series of one-day measurements (in terms of the largest values), in which the maximum sulfur dioxide concentrations were found to be 10 times lower than the MPC level. Of 486 strictly maximum single concentrations, 146 were taken for the validation of the highest zonal values. The zone where the largest concentrations were observed was found to lie between 1 and 5 km from the discharge source, i.e., amounted to approximately 6-30 smokestack heights H = 180 m. The largest maximum concentration, 0.364 mg/m^3, was observed at a distance of 4 km (about 20 H is the theoretical X maximum). It exceeded the maximum calculated value of 0.270 mg/m^3 by approximately 30%. This excess may be partly explained by the fact that the point of collection of the air samples was located behind a water reservoir (it is known that a plume tends to descend over a water surface) and by the fact that this territory was located 40-50 m above (steep shore) the industrial area. The extreme concentrations (10 samples) are higher than the significant maximum single values and at distances of 2-3-4 km even correspond to the MPC level. In the zone where the largest concentrations were observed, most of the frequently occurring maximum single concentrations (averaged maximum values) are approximately 0.1 mg/m^3, i.e., substantially below the zonal concentrations calculated from the "temporary method". It should be noted that the lower temperature of the flue gases discharged after passing through wet rod-type VTI ash collectors under the climatic conditions of the area around SREPP-3 caused the maximum calculated value obtained by the "temporary method" to be higher than that obtained from Andreyev's formula 0.207 mg/m^3 at V_0 = 4.5 m/sec.

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* See this collection, p. 52.

Thus, the studies of 1964-65 support the conclusion that the use of the "temporary method" for the prognostic determination of the probable maximum gas and dust content of atmospheric air of populated areas due to discharges from newly planned or modernized thermal electric power plants is fully justified from a sanitary standpoint.

However, considering the detected tendency of sporadic actual (extreme) values to exceed the maximum calculated values and also the slight excess of the largest significant values over the calculated ones, on the initiative of the F. F. Erisman Institute, a step permitting one to increase the final calculated concentration by 25% while allowing for the worst meteorological conditions has been introduced into the formulation of the procedure for calculating the dispersal.

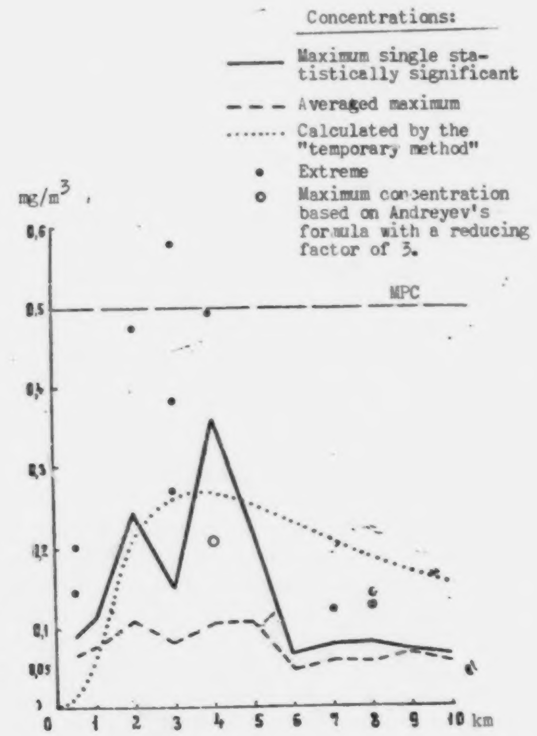

Fig. 3. Distribution of maximum concentrations of sulfur dioxide in the atmosphere in the area of SREPP-3 (actual and calculated values in mg/m^3).

The earlier-determined boundaries of the zone of observation of maximum impurity concentrations in the ground layer of the atmosphere -- the smoke pollution zone in the range of 10-40 smokestack heights -- have also been confirmed.

STUDY OF THE HEALTH OF THE JUVENILE POPULATION RESIDING IN AREAS WITH VARIOUS DEGREES OF POLLUTION OF THE ATMOSPHERE BY EMISSIONS FROM STATE REGIONAL ELECTRIC POWER PLANTS (SREPP)

R. S. Gil'denskiol'd, Ya. K. Yushko, G. N. Tyurina, and V. P. Dukhanova

From Ministerstvo Zdravoochraneniya RSFSR. Moskovskiy Nauchno-Issledovatel'skiy Institut Gigieny Im. F. F. Erismana. "Voprosy gigieny atmosfernogo vozdukha i planirovki naselennykh mest". Uchenye zapiski, Moskva, p. 75-80, (1968).

Comprehensive zonal studies of pollution of the ground layer of atmospheric air with sulfur dioxide and dust (fly ash) conducted for many years in a radius up to 20 km from the smokestacks of SREPP with simultaneous recording of the physical parameters of the state of the atmosphere and production and operational indicators of electric power plants have culminated in the development of a method, now in use, for calculating the dispersal of discharges from SREPP and thermal electric power plants in atmospheric air, based on the modern theory of turbulent diffusion.*

The studies were performed in different seasons of the year around an electric power plant operating on low-calorie, high-ash and high-sulfur fuel with smokestack heights initially at 120 m and lately 120 and 180 m.

The total number of air samples to be analyzed for sulfur dioxide, collected by the suction method under the smoke plume of the SREPP from 1961 through 1965, was 11831, and those to be analyzed for dust, 2066. The maximum sulfur dioxide concentrations in the most heavily smoke-polluted zone (10-40 geometric stack heights) were 3.30-4.03 mg/m^3 based on extreme concentrations and 2.5-4.62 mg/m^3 based on dust; this was 5-9 times greater than the MPC. The zone closest to the SREPP, approximately 1 km, was characterized by a considerably lighter pollution of atmospheric air; based on averaged maxima (frequently occurring highest single concentrations), the gas content was found to be 1.0-1.6 mg/m^3, and the dust content, 1.4-1.5 mg/m^3. A distance of 15 km for both dust and sulfur dioxide was the maximum distance where the highest single concentrations at the MPC level were still found in atmospheric air.

The regularity detected in the dynamics of propagation and diffusion of noxious substances through atmospheric air confirms the argument that for a high point-emission, the bulk of the toxic substance continuously diluted in the atmosphere is transported by the air masses to a certain distance (the so-called throwover zone) determined by the physical state of the atmosphere, and then, on settling, comes in contact with the ground (smoke pollution zone). Farther on, as a result of the dispersal, the observed ground concentrations gradually decrease.

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* The setup, methods, and results of the studies were published in Transactions of the A. I. Voeykov Main Geophysical Observatory, nos. 138, 158, and 172 for 1963-1965, and Scientific Reports of the F. F. Erisman Institute "Aspects of Sanitary Planning and Protection of Atmospheric Air," 1966.

In order to study the influence of the emissions of the SREPP on the health of the population residing in areas with different degrees of atmospheric pollution, a comprehensive medical survey of the physical development and health of the most vulnerable juvenile population -- 9-10-year-old schoolchildren -- was carried out in three areas (Fig. 1):

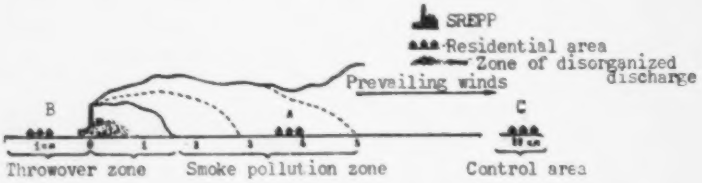

Fig. 1. Diagram of vertical cross section of smoke plume and location of the main and control areas relative to the SREPP.

Main area A, is the smoke-pollution zone, where the largest concentrations of sulfur dioxide and dust were observed in atmospheric air. The survey was made on school children living in a residential area at a distance of 3.5-4.0 km from the source of atmospheric pollution. The relative location of the town and SREPP is very unfavorable from the standpoint of the direction of the prevailing winds. During the course of the year, more than 40% of the winds are directed from the SREPP toward the town, this being responsible for the protracted action of substantial pollutant concentrations on the population. Interrogation of the population of the area showed that over 95% of those questioned complained of the unpleasant odor and dustiness of the air when the wind was blowing in this direction. Coughing, difficult breathing, dust in the eyes, adverse effect on the sanitary living conditions and a deleterious influence on green plantings were also noted.

Main region B is the zone of throwover of the smoke cloud. Strictly speaking, there is no such zone when the SREPP operates on solid fuel, since in the immediate vicinity of the smokestacks there are additional, continuously acting, less intense, disorganized sources of atmospheric pollution with dust and sulfur dioxide. They include an open coal dump, transport (shunting locomotives), and the settling of coarse zonal particles from the smoke cloud under the influence of gravity forces, etc. However, considering that the existing town of the power workers is located on the windward side relative to the SREPP and that the influence of disorganized discharges in the course of the year is minimal, the survey was made on students of the school serving the residential area of the town, located at a distance of 800-1200 m from the source of the principal organized emission.

Control area C is the zone of relatively pure atmospheric air. Schoolchildren living in a residential area at a distance of 20 km from the SREPP were studied. According to our results, the area may be evaluated as a zone of insignificant atmospheric pollution (the extreme highest single concentrations did not exceed 0.3 mg/m^3).

Aside from the main problem, the data of the study could serve as an indirect objective proof of a constant presence of a regular pattern, detected as a result of the field investigations, in the behavior of the smoke plume in the area of the large-output organized industrial source of atmospheric pollution.

The medical survey included anthropological, clinical, physiological, x-ray, biochemical, and other methods of investigation.

The total number of children studied was 677, of whom 227 lived in neighborhood A, 235 in area B, and 215 in area C. These groups were similar in age-sex composition. Their social position, material situation and living conditions were basically the same.

Analysis of the indicators of physical development of the children's groups studied revealed a generally satisfactory correspondence to the basic physiological norms in all three areas, but the indicators of average annual weight gain, circumference of the chest, and growth (in both girls and boys) were somewhat lower in those residing in area A as compared with the corresponding values in areas B and C, which were practically equal.

A more pronounced dependence was detected between the number of complaints voiced during the survey and the degree of pollution of atmospheric air (Table 1).

Table 1

Complaints Voiced by Schoolchildren in Three Neighborhoods, %

Complaints	Main Areas		Control
	A	B	C
Headache	30,5	20,4	15,3
Cough, head cold	15,8	8,2	5,4
Rapid fatigability	12,3	10,2	6,3
Other	5,3	4,2	3,1
No complaints	36,1	57,0	69,9
Total	100,0	100,0	100,0

As follows from Table 1, the largest number of complaints were voiced by children residing in area A - a total of 63.9%; they were considerably fewer in area B - 43.0%, and still fewer in area C - 30.1%. The schoolchildren living in the zone of lasting, heavy smoke pollution of the atmosphere voiced 2-2.5 times as many complaints as those in the group of area C. The difference established in terms of these indicators between the groups of areas B and C were slight. The percentagewise expression of the number of children who did not voice any complaints indicates an approximately double magnitude of the indicators for area C as compared with area A.

Table 2

Disorders of the Upper Respiratory Tract of Schoolchildren in the Three Neighborhoods (For 100 Subjects)

Pathologic Processes	Main Areas		Control
	A	B	C
Disorders of upper respiratory tract	39,7	26,3	22,8
Including:			
Chronic Tonsillitis	20,3	14,5	13,5
Hypertrophic rhinitis and rhinopharyngitis	6,6	3,8	2,8
Atrophic rhinopharyngitis	4,0	2,5	2,3
Adenoids	2,6	1,7	1,4
Chronic laryngitis	6,2	3,8	2,8

An otolaryngological survey revealed an increase in the incidence of disorders of the upper respiratory tract in schoolchildren of the two main areas as compared with the control (Table 2); in the smoke pollution zone A, certain nosological forms indicated that the number of illnesses was twice as high as in area C.

The predisposition to the development of chronic inflammatory disorders of the upper respiratory tract in children residing in the gas-polluted area may be regarded as one of the manifestations of a prolonged action of SREPP emissions (sulfur dioxide and ash) on the children's orgamism. However, no substantial changes in the lung tissue was detected by x-rays.

Data from the functional study of the cardiovascular system confirm the detected regularity - a decrease in the functional capacity of the heart was observed in children of area A. In this group, a decreased content of blood hemoglobin was observed in a large number of students (25.1%), as against 22.5% in area B, and only 10% in area C.

Data of a thorough neurological survey conducted on a smaller contingent of the same groups of students in the lower grades (210 people) show the prevalence of functional disorders of the central nervous system precisely in children of area A. Thus, an increased fatigability, weakening of muscular strength, decline of memory, and slowing down of perception and certain other indicators in the smoke pollution zone were observed twice or more times as frequently as in the control area. As a rule, these indicators in children residing in the throwover zone of the plume, B, were close in frequency to the level determined in area C.

As a result of biochemical studies, the presence of sulfur dioxide was detected in the blood of children of area A, ranging from traces to 0.02 mg% in 91% of the subjects, with the highest concentrations, 0.01 and 0.02 mg%, found in the blood of seven children. In area B, the presence of sulfur dioxide in the blood was found in 18% of the schoolchildren in the group surveyed, and the maximum concentration in one case reached 0.01 mg%. In schoolchildren of area C, only traces of sulfur dioxide in the blood were observed in 18% of the cases.

The presence of sulfur dioxide in the blood objectively indicates a prolonged presence of high concentrations of this substance in the atmospheric air of residential area A, since no sulfur dioxide should be found in the blood of persons living in an area that is clean from the sanitary-hygienic point of view.

An indicator of the adverse effect of sulfur dioxide on the organism and its defensive function was a decrease in the content of ascorbic acid in the blood and a decrease in the amount of vitamin C excreted with the urine, observed in children of area A, as compared with higher and approximately equal values determined in groups residing in areas B and C.

Thus, the findings of the above medical survey of schoolchildren show beyond any doubt that in the zone of frequent smoke pollution, where the highest single concentrations of sulfur dioxide and fly ash exceeded the MPC severalfold, conditions develop which are not permissible from a sanitary standpoint, and are responsible for a debilitation of the developing child's organism and lead to chronic disorders.

A clinical confirmation of the presence of the throwover zone of the plume, i.e., a region with a slight atmospheric pollution, makes it possible to recommend that planned layouts of the residential settlement near an isolated SREPP specify a gap of no less than 1000 m between the latter and the former.

In order to minimize the adverse effect of SREPP emissions on the health and living conditions of the population, on the recommendation of the F. F. Erisman Institute, the project of modernization of the electric power plant has been made to include the following measures:

1. Conversion of the SREPP to enriched coal. Instead of the brown coal being used at the present time with a sulfur content up to $S^p = 3\%$ and ash content A^p up to 30%, a coal with $S^p = 1.6\%$ and $A^p = 21.5\%$ will be supplied.

2. Increase of the degree of removal of fly ash from stack gases in the existing part of the SREPP to 94.4% (at the time of the study, 87-90%) and in the part undergoing expansion, up to 98%.

3. Replacement of four existing smokestacks 120 m high with an output of 610 MW by a single stack 250 m high. After the SREPP is modernized, there will be two operating stacks - 250 m and 180 m in the part being expanded (400 MW).

4. Use of excess natural gas in combustion during the summer (it has been taking place periodically since 1963).

Calculation by the "Temporary Method for Calculating the Atmospheric Dispersal of Emissions (Ash and Sulfur Compounds) from the Smokestacks of Electric Power Plants" shows that the implementation of these measures in conjunction with a stable and efficient operation of the purification equipment will lower the sulfur content in the ground layer of the smoke pollution zone to 0.47 mg/m^3, and the dust content to 0.15 mg/m^3, i.e., the pollution level of atmospheric air will be below the established highest single maximum permissible concentrations in the residential area for these substances, equal to 0.5 mg/m^3.

ATMOSPHERIC POLLUTION CAUSED BY REFUSE DUMPS

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From Materialy Pervoy Ukrainskoy konferentsiii "Rasteniya i promyshlennaya sreda" Akademiya Nauk Ukrainskoy SSR. Tsentral'nyy respublikanskiy botanicheskiy sad. Izdatel'stvo "Naukova dumka". Kiev p. 38 - 45 (1968).

Refuse dumps are engineering structures resulting from the stockpiling of rock produced by the mining of coal and its preparation. Most of them are active. As a result, the dumps are a source of atmospheric pollutants that are spread by air currents over considerable distances. They include gases evolved by the conbustion of the refuse dumps, and suspended coal and rock dust formed by the dumping of the rock and its weathering. The exhaled substances have a destructive effect on the fauna and flora and also affect the health of the people residing near the dumps.

Thus, the complete elimination or reduction of the emission of these noxious substances is a problem of the first magnitude whose practical solution requires a determination of the causes of their formation.

From the standpoint of their shape, refuse dumps are divided into four types: 1) refuse heaps, 2) crested, 3) flat, and 4) combined dumps.

The predominant form are refuse heaps, which comprise 80.9% of the total amount of dumps. Each year, the volume and height of the dumps increase. At the present time, 31.7% of the dumps are 50 m high or higher. It is expected that as coal mining increases, so will the flow of the dump mass.

A dump consists of the rock mass, which for each pit, contains a definite amount of limestone, sandstone, clay shales or sandy shales, and combustible materials (coal, wood, etc.).

Upon coming in contact with air, the rock changes its physicomechanical properties under the influence of the atmospheric conditions: it becomes fragile and breaks up. The finest particles of the dump mass are detached from the dump by the air currents and carried away, polluting the air of neighboring areas. In addition, the atmospheric air becomes heavily charged with dust as a result of unloading of the rock on heaps and crested dumps.

We conducted studies to determine the degree of dust pollution of air around refuse dumps around the "October" pit of the Kuybyshevugol' trust and the "East" pit of the Proletarskugol' trust. The selection of the dumps took into consideration their type, accessibility from all sides, and absence of the influence of other sources on the atmospheric air around them. At the

"October" pit, the refuse dumps consisted of two heaps (maximum height 50 m) and a flat dump adjacent to them; at the "East" pit, of a flat dump (height 30 m) and crested dumps.

Measurement data on the dust pollution of air in the Don Basin (Tables 1, 2, and 3) show that: 1) the heaviest dust pollution of air around refuse dumps is observed during the summer months; 2) the dust pollution of air produced only by the weathering of refuse dumps is relatively moderate; 3) comparison of the weighted mean dust content of air near heaps and crested dumps along the outline of the sanitary protective zone shows that it is approximately five times greater near the crested dumps than near the heaps; 4) the dust content of air at a distance of 2000 m from the dumps in many cases exceeds the sanitary permissible norms.

Table 1.

Concentration of Dust in mg/m^3 in Atmospheric Air as a Function of the Distance from Dumps of the "East" Pit.

Distance from Dump, m	Dust Content of Air, mg/m^3						
	5.V 67.	21.VI 67.	6.VII 67.	26.VIII 67	22.IX 67.	20.X. 67.	22.XI.67
0	I,0	3,3	-	2,8	-	0,44	-
I00	5,0	6,3	3,6	6,7	I,08	0,6	0,6
200	-	8,6	-	-	-	0,86	-
300	4,0	2,2	-	3,3	-	0,44	-
500	-	9,6	-	4,5	4,2	I,8	-
I000	4,0	2,2	2,6	I,6	-	-	-
I500	5,0	2,3	-	2,2	-	2,4	-
2000	-	-	-	-	6,3	I,3	-

In addition to exhaling dust, refuse dumps also emit noxious gases whose amount depends on the combustion rate of the refuse dumps. Observations show that refuse heaps and crested dumps burn most rapidly (Table 3) and hence emit the largest amount of fire gases.

The increased resistance of heaps and crested dumps to combustion is explained as follows. When the rock is stockpiled in heaps and crested dumps, it becomes distributed (segregated) according to the particle size and density: the finest fractions deposit at the top, coarser ones lower, and the coarsest ones, in the lowest part of the dumps. Combustible materials are also arranged unevenly over the slope: their maximum quantity is located at the top, and a minimum quantity at the base of the dump.

Table 2.

Concentration of Dust in mg/m^3 in Atmospheric Air as a Function of Distance from Dumps of "October" Pit.

Distance from Dump, m	Dust Content of Air mg/m^3			
	I6.VI.67.	29.VI.67.	20.IX.67	20.X.67
0	49,4	-	-	0,6
I00	I6,I	-	-	I,2
200	8,6	-	-	2,0
300	2,I	-	0,24	3,0
500	I,0I	0,3	-	2,0
I000	3,2	0,4	-	I,0
I500	7,5	-	-	-
2000	5,4	0,5	0,24	0,6

Table 3.

No.	Type of Dump	Total	Of these, Undergoing Combustion	
			Quantity	%
I.	Refuse Heaps	I930	II36	58,9
2.	Crested Dumps	86	64	74,4
3.	Flat Dumps	37I	60	I7,2

Because of this distribution of the rock, the density of a dump changes from the top to the base: the top of the dump, composed of fine fractions, is the densest, whereas the lowest part (approximately 1/3 of the dump) is readily penetrated by air. After passing through this zone, the air reaches a denser zone with a higher content of combustible materials, and the latter are oxidized, evolving heat. The heated air is driven upward, producing a draft, i. e., the influx of fresh amounts of atmospheric oxygen causes heating of the upper layers of the rocks, preparing them for participation in spontaneous combustion. The combustible materials ignite spontaneously when the amount of heat generated by the low-temperature oxidation of the rocks exceeds the amount of heat given up to the surroundings. This process takes place only at points where conditions favoring it prevail, and it is therefore focal in character. The combustion of rocks subsequently spreads over the surface of the dumps; at points where it arises, it is sustained by the influx of fresh dump mass.

The following gases are evolved during the combustion: CO_2, CO, H_2, H_2O, CH_4, SO_2, H_2S, which rise above the dump by convective currents and are spread by currents of atmospheric air over the grounds adjacent to the dump.

The distance to which the gases are carried and their concentration depend on the combustion rate of the dumps, meteorological conditions, and roughness of the underlying surface.

The combustion rate of the dumps affects the temperature of the fire gases evolved, the heating of the atmosphere surrounding the dump, and hence the height of the vertical ascent of the gases. However, this height of ascent is also influenced by the meteorological conditions, i. e., the air temperature and wind velocity. A high air temperature and minimum wind velocity promote an increase in the height of ascent of the gases; a low air temperature and maximum wind velocity decrease it.

On rising, the fire gases mix with air, causing an equalization of their temperatures. Moving along with the air, the fire gases are subjected to mechanical and thermal turbulence and descend to the earth's surface. At the point of contact of these air masses with the earth's surface, there is observed a maximum concentration of gases which gradually decreases with increasing distance from this point.

We conducted studies of the degree of gas pollution of the atmosphere over the territory adjoining the refuse dumps of the "October" pit of the Kuybyshevugol' trust and "East" pit of the Proletarskugol' trust.

The samples were selected monthly on the leeward side of the dumps at the base and at distances of 100, 200, 300, 500, 1000, 1500, and 2000 m from them. The days of the selection were chosen so that it would be possible to determine the distribution of the fire gases in all the directions relative to the dumps.

In the course of these studies, only SO_2 was detected at all the observation points (Table 4); the gases H_2S, CO, and CO_2 were detected only at certain points. These data show that: 1) the SO_2 concentration may vary over a wide range at each observation point; 2) there is no linear relationship between the distribution of concentration of the gases and the distance from the dumps to the point of sample collection; 3) the maximum concentrations of sulfur dioxide are found at a distance of 100-300 m from the dumps, and decrease beyond that; 4) at a distance of 2000 m from the dump, the highest single concentration of sulfur dioxide is 6-7 times greater than the maximum permissible concentrations in the atmospheric air of populated areas.

Table 4.

Concentration of SO_2 in Atmospheric Air in mg/m^3 as a Function of Distance from Dump.

Pit	Number of Analyses	Distance of Point of Sample Collection from Dump, m							
		I00		500		I000		2000	
		Max.	Av.	Max.	Av.	Max.	Av.	Max.	Av.
"October"	II	II,2	2,82	2,8	I,27	3,7	I,I6	3,0	0,77
"East".	8	4,6	2,8I	3,7	I.73	II,3	3,9I	3,7	I,00

Since refuse dumps have thus far been unavoidable, steps should be taken toward controlling the emission of noxious substances associated with their use. In our view, such measures should consist in the following: 1) new dumps should be formed at sufficient distances from populated areas; 2) the rocks should be stockpiled in dumps of flat shape; when the rock is stockpiled in dumps, steps should be taken to prevent spontaneous combustion of the rocks and dust formations; 4) quenching of the combustion of rocks should be carried out on actively burning dumps; 5) inactive dumps should be planted with greenery.

SANITARY CHARACTERISTICS OF AMMONIA AND VALIDATION OF ITS MAXIMUM PERMISSIBLE CONCENTRATION IN ATMOSPHERIC AIR

M. M. Sayfutdinov

From Ministerstvo Zdravoochraneniya RSFSR. Moskovskiy Nauchno-Issledovatel'skiy Institut Gigieny Im. F. F. Erismana. "Voprosy gigieny atmosfernogo vozdukha i planirovki naselennykh mest". Uchenye zapiski, Moskva, p. 62-65, (1968).

The vigorous growth of the chemical industry in the Soviet Union has led to the development of many areas of production. There has been a sharp increase in the production of ammonia, which has broad applications and is one of the key products in modern chemical industry. The number of sources discharging ammonia into the atmosphere is proportionately increasing.

Studies of the quantitative content of ammonia in atmospheric air have been very limited. Depending on the pollution source, the ammonia concentration in atmospheric air ranges from 0.015 to 57.0 mg/m^3, and in air where there are no special pollution sources, from 0.003 to 0.05 mg/m^3 (V. A. Ryazanov, 1961; Z. D. Markova, 1921; V. A. Kononova, 1963).

Thus far, the maximum permissible concentration of ammonia in atmospheric air has not been established. We therefore undertook the task of studying the actual content of ammonia in atmospheric air around a ferrous metallurgical plant and establishing its maximum permissible concentration in atmospheric air through experimental investigations of the influence of low concentrations on man and animals.

In determining the ammonia concentration in air, we used colorimetric methods: with Nessler's reagent (S. M. Bykhovskaya et al., 1960), and the indophenol reaction (M. P. Poletayev and N. A. Andreyeva, 1959).

The pollution of atmospheric air with ammonia was studied during 1963-1965 around the Novolipetsk metallurgical plant, where the sources of emission of ammonia are the by-product coke and nitrogen fertilizer sections.

The studies were conducted at distances from 500 to 7000 meters.

The results are shown in the table.

The highest ammonia concentrations are observed at distances of 500 and 1000 m.

The high gas concentrations in 1965 as compared with previous years are due to the start of nitrogen fertilizer production.

The effect of low concentrations of ammonia on the physiological reactions of man were studied by determining the threshold of its action on the sense of smell, light sensitivity (by the method of adaptometry) and electric activity of the brain (by recording the total electric activity of the brain).

Table

Concentration of Ammonia in Atmospheric Air Around Novolipetsk Metallurgical Plant (Maxima and Averages of Maximum Single Values in mg/m^3)

Distance in Meters	Ammonia, mg/m^3					
	1963		1964		1965	
	Maximum	Average	Maximum	Average	Maximum	Average
500	1,4	0,31	3,6	0,62	4,68	2,19
1000	3,5	0,5	0,39	0,185	1,73	0,91
3000	2,25	0,45	1,3	0,26	0,39	0,248
5000	0,2	0,16	0,5	0,10	0,28	0,223
7000	0,2	0,09	0,3	0,03	0,173	0,163
10000					0,130	0,121

The threshold of olfactory perception was determined on 22 persons. A total of 432 tests were performed. In the most sensitive persons, the threshold of olfactory perception was found to be 0.055-0.50 mg/m^3, and the maximum imperceptible concentration, 0.45-0.40 mg/m^3.

The adaptometric studies were conducted by using a model ADM adaptometer. Fifty-three observations on three persons were made. It was found that an ammonia concentration of 0.45 mg/m^3 caused a decrease in the light sensitivity of the eye in two subjects, while a concentration of 0.32 mg/m^3 was found to be inactive for them.

In the third subject, a drop of the light sensitivity curve occurred under the influence of an ammonia concentration of 0.65 mg/m^3. No changes were caused by a concentration of 0.50 mg/m^3.

The electroencephalographic study was made by using the method of functional encephalography proposed by A. D. Semendnko (1963).

Changes in the biopotentials of the brain were recorded with an eight-channel electroencephalograph of the Kaiser Co. The tests were conducted on five subjects.

The action of the gas in a concentration of 0.36-0.35 mg/m^3 caused a decline in the total bioelectric activity in two subjects and a reinforcement in one. For the same subjects, ammonia in a concentration of 0.22 mg/m^3 was found to be inactive.

In the remaining two subjects, a reinforcement of the bioelectric activity of the brain was noted under the influence of the gas in a concentration of 0.44 mg/m^3. An ammonia concentration of 0.32 mg/m^3 was found to be inactive for them.

The electroencephalographic data showed the highest single maximum permissible concentration of ammonia in atmospheric air to be 0.2 mg/m^3.

In order to study the resorptive effect of low ammonia concentrations, white rats were subjected to a round-the-clock chronic exposure for 84 days. The animals were divided into four equal groups of 15 in each. One of them was the control. Of the other three, the first group was subjected to the action of 20 mg/m^3 of ammonia, the second to 2 mg/m^3, and the third, to 0.2 mg/m^3. Observations of the general state of the animals, their weight, and the latent reflex time were performed in the course of exposure. In the blood, the cholinesterase activity, oxidation-reduction function, hemoglobin, erythrocytes, fluorescent* leucocytes, and nucleic acids, and in the urine, coproporphyrin and ammonia were determined. After the completion of exposure and after the recovery period, a pathomorphological analysis of the organs and tissues were made on some of the animals.

Under the conditions of the exposure, ammonia had no appreciable effect on the general state and weight of the animals.

The latent time of the reflex response was measured on the "chronoreflexogenometer" proposed by S. I. Gorshkov (1964). A significant shortening of the reflex time was established in the first group of rats during the first month of exposure under the influence of 20 mg/m^3 of ammonia.

The blood cholinesterase activity was studied by the method of Fleisher and E. Paupe modified by N. N. Pushkina and N. V. Klimkina (1964). Ammonia in a concentration of 20 mg/m^3 caused a depression of cholinesterase activity.

The oxidation-reduction function of the blood serum was determined by a modified method of Gumberg (Yu. L. Apin, 1964). The method is based on a change in the color of methylene blue with blood serum upon boiling in a water bath, and on the measurement of the time necessary for complete decolorization. In our studies, a lengthening of the time of complete decolorization took place in the first and second groups of rats as compared with the control group.

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* Editor's note: For the Russian terms "luminescent" and "luminescence" in this paper, we have substituted "fluorescent" and "fluorescence" on the basis of the definitions of these terms.

Studies of the hemoglobin, erythrocytes, fluorescent leucocytes and nucleic acids in the blood of the experimental groups did not show any appreciable changes as compared with the control group.

Coproporphyrin in the urine was determined spectrophotometrically (M. I. Gusev and Yu. K. Smirnov, 1960). During the exposure, an increase in the excretion of coproporphyrin was noted only in rats of the first group.

The ammonia content in the urine was studied by the Sorensen-Ronchese method (1963). The results showed an increased content of ammonia in the urine of rats of the first group.

Pathologico-anatomical, histological and histochemical studies using standard methods did not reveal any changes in the internal organs or central nervous system in animals of the experimental group as compared with the control.

Thus, in chronic exposure of white rats, ammonia in a concentration of 20 mg/m^3 causes changes in the functional state of the nervous system, a depression of cholinesterase activity and oxidation-reduction function of the blood, and also an increase in the excretion of coproporphyrin and ammonia with the urine. An ammonia concentration of 2 mg/m^3 caused a change in the oxidation-reduction function, while ammonia at a level of 0.2 mg/m^3 had no effect on the organism of the experimental animals.

Conclusions

1. The by-product coke and nitrogen fertilizer sections of a metallurgical plant are the most important sources of pollution of atmospheric air with ammonia.

2. The threshold concentration causing no change in the biopotentials of the brain is 0.22 mg/m^3, and this level was adopted as the highest single maximum permissible concentration of ammonia in atmospheric air.

3. The minimum active ammonia concentration in a round-the-clock exposure of white rats was 2 mg/m^3, while a concentration of 0.2 mg/m^3 was found to be inactive.

4. The mean daily maximum permissible concentration of ammonia in atmospheric air is recommended on the same level with the highest single maximum permissible concentration, i.e., 0.2 mg/m^3.

OZONE CONCENTRATIONS IN THE LOWER STRATOSPHERE HARMFUL TO MAN

Professor A. Kh. Khrgian

From Glavnoe Upravlenie Gidrometeorologicheskoy Sluzhby Pri Sovete Ministrov SSSR. "Meteorologiya i Gidrologiya", No. 4. Moskovskoe Otdelenie Gidrometeoizdata, Moskva, p. 10-15, (Aprel' 1969).

The paper examines data from observations of ozone concentrations in the atmosphere, carried out in the U.S.A. and in Western Europe. The analysis performed is of importance in practical forecasting of weather and airplane flight conditions in the lower stratopshere.

As a result of the development of aeronautical engineering in the last decade, an increasing number of flights are made in the lower stratosphere at altitudes that increase steadily every year. Since jet engines are most economical when the external air pressure is low, the trend toward speed and long-range flights forces the airplanes to rise ever higher, and the time is near when major passenger airlines will be flying airplanes at Mach numbers of 2 at altitudes of 20 km or higher. Military aviation (for example, rocket planes, etc.) has long since stepped over this threshold, and pilots are interested in flight conditions not only in the lower, but also in the upper stratosphere.

One of the problems which thus arise is that of elimination of the harmful effect of the relatively high ozone concentration in the stratosphere on the health of the passengers and crew and on certain aeronautical materials. Thus, the destructive action of ozone on rubber (it is known, for example, that there even exists a method of measuring ozone from the degree of cracking of rubber films), which is very dangerous, particularly because it impairs the pressurization of the airplane, is very important, but will not be discussed here.

Physiological experiments show that even slight ozone concentrations may have an effect on man and animals, mainly on their respiratory system. At a concentration of 10^{-6} (by volume), man begins to perceive the characteristic odor of ozone; in the open air, this was noted, for example, at the Jungfraujoch Observatory in the Alps at an altitude of 3500 m. Back in 1927, Dadle observed that at a volume concentration of about 0.8 x 10^{-6} (units of 10^{-6} will be used hereinafter), man begins to feel ill in only half an hour, and the experiments of Klaman and Banvroft in 1959 showed that symptoms of irritation and impairment of the function of the respiratory system appear at a concentration of only about 2, even in young people. A concentration of 60 was lethal for rabbits and rats.

Somewhat earlier, in 1955, a conference of American industrial hygienists indicated that for a working day lasting 8 hours, the maximum permissible concentration of ozone in industrial buildings should be no higher than 0.1.

On the basis of the above and considering the short-lived character of the action of ozone on the crew in high altitude flights (of the order of 1-2 hours), we shall consider below the conditions when the ratio of the mixture (concentration by weight) will reach the value $r_1 = 1 \times 10^{-6}$ in the stratosphere, which corresponds to a concentration by volume equal to 1.66 and is the lower limit of harmful effects of ozone. As the toxic dose corresponding to intolerable conditions in the aircraft cabin we shall take a concentration 5 times as high ($r_2 = 5 \times 10^{-6}$). We shall also assume that the ozone concentration in the external air sucked in and pressurized before entering the cabin remains unchanged in this process.

The photochemical theory of atmospheric ozone states that the ozone concentration is insignificant in the troposphere, then increases in the stratosphere to altitudes of 30-35 km, and above that decreases again. If in addition one takes into account the vertical movements of air, which also considerably determine the pollution of stratospheric air with ozone, the layer of high ozone concentrations may descend, or, more accurately, substantially expand downward, into the lower stratosphere. In individual, probably exceptional cases, it may descend to an altitude of about 5 km, as was the case, for example, above Thule on 27 February 1963. Experience shows that this descent and expansion of the layer take place most frequently at high latitudes in winter and spring. Such a process simultaneously leads to an increase in the total amount of ozone. As was shown by Kh. Dyutsh, the correlation coefficient between ozone of the lower stratosphere at altitudes of 11.5 and 19 km and the total amount of ozone reaches 0.7-0.8 in winter and spring. Thus, the increase in the total amount of ozone constitutes a fairly good indication of the increase in the amount of ozone in the lower stratosphere that is of interest to us in this article.

Tropical and subtropical latitudes (up to 35°C. N and S) are pratically insured against these strong temporary increases of ozone, but nevertheless, as will be shown below, the ozone concentration at these latitudes in its main layer in the middle stratosphere is always high and as a rule exceeds the danger threshold.

In order to analyze the question of toxicity of stratospheric air in greater detail, we treated certain statistical data of observations on the vertical distribution of ozone in the lower stratosphere, made by means of ozone probes. These observations have as yet been few in number and for the most part cover the temperate latitude belt. Of greatest interest from the standpoint of the given problem is the belt of high latitudes, which unfortunately has been studied thus far only in a very small number of vertical soundings by means of an ozone probe. We obviously take the fullest possible advantage of these soundings.

The existing more extensive observational material obtained by the optical method of reversal pertains to a large number of points of the globe and could therefore be of particular interest to us. However, it has one essential drawback in this case. The reversal method, even in its newest version using a computer, makes it possible to determine the average amount of ozone in nine fairly thick layers, of which only the second, from 250 mb (10.3-14.8 km based on the standard atmosphere) is of interest to us. The existing tabulations of ozonometric data indicate only the average partial pressure of ozone p_3 in this large layer. In individual thinner layers of the lower stratosphere, p_3 can obviously be appreciably higher than this highly averaged p_3.

With these qualifications, we shall nevertheless consider the available data.

First of all, let us turn to the average vertical distribution of p_3 in micromillibars (μmb) for different areas of the globe, as given by Kh. Kÿutsh. We are of course most interested in data of observations made in the spring, when the amount of ozone reaches its maximum. Figure 1 a shows curves of the average vertical distribution of ozone above Resolute (Canadian Arctic archipelago, 75° N), Uppsala (60° N), Arosa (47° N), Aspendale (38° S), Mount Ebu (26° N) and Leopoldville (4° S). The figure shows curves for the weight concentration $r_1 = 1 \times 10^{-6}$, which, as we have stated, should be considered the lowest that still has an effect on the human organism, and $r_2 = 5 \times 10^{-6}$, which already is undoubtedly a toxic dose of ozone.

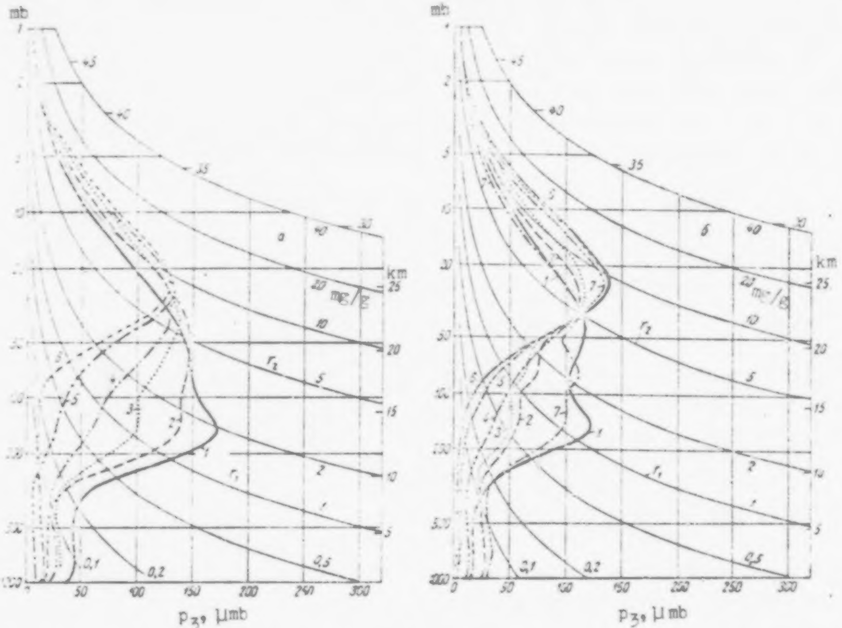

Fig. 1. Average vertical distribution of ozone in spring and fall after Kh. Dyutsh. 1 - Resolute, 2 - Uppsala, 3 - Arosa, 4 - Aspendale, 5 - Mount Ebu, 6 - Leopoldville-Kinshasa, 7 - Argentine Islands (65°S). Fine curves - isolines of ozone concentration in g/g.

It is quite obvious from Fig. 1a that on the average, in the spring, the value of r_1 occurs above polar latitudes at an altitude of only 11 km (and higher), above temperate latitudes at 12-13 km, and above tropics and the equatorial region, at 18-19 km. Above these levels, the harmful influence of ozone during flight will be noticeable in the majority of cases. The toxic value of r_2 is observed (again on the average) at altidudes of 21-22 km. In comparison with this value, the difference between the latitudes is much smaller than in comparison with r_1. Air above 21-22 km is equally harmful above almost all the latitudes. The maximum values $r = 13\text{-}14 \times 10^{-6}$ are typical chiefly of the tropical belt above 26 km.

Figure 1 b shows analogous curves for the fall season. The shape of the vertical distribution curves is generally analogous to that observed in the spring, but the amount of ozone in the stratosphere below 20 km is much less in the fall than in the spring. Correspondingly, also the value of r_1 can be found on the average at greater heights: above Uppsala and Arosa, for example, above 16-17 km. In this respect conditions for flights in the lower stratosphere in the fall are substantially more favorable than in the spring. This seasonal difference is maintained in polar and in temperate zones. Even in the upper stratosphere, above 25 km, the ozone concentration, in general is lower in the fall than in the spring.

In the tropical zone, however, the difference between fall and spring in the upper stratosphere is slight, and of no practical importance.

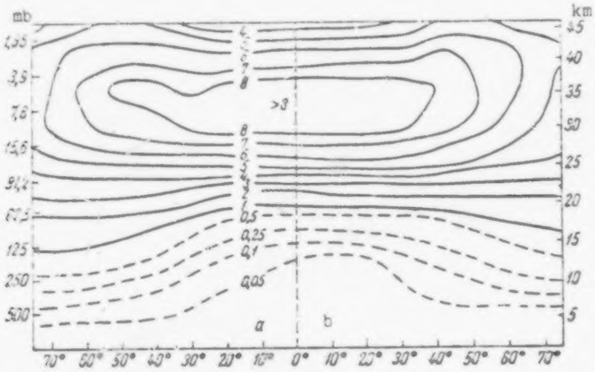

Fig. 2. Average concentration of ozone (by weight) as a function of altitude, µg/g, in March-April (a) and September-October (b).

Of particular interest in Fig. 1 b are data for Argentine Islands in Antarctica (65° S). The amount of ozone there is almost as high as during the fall hemisphere above the Arctic. Obviously, within the confines of this latitudinal belt, the Antarctic is just as dangerous as the Arctic, and only the "gap" existing above the South Pole in the total amount of ozone can also affect the concentration of ozone in the lower stratosphere. However, this hypothesis must still be verified.

Figure 2 illustrates in more detail the latitudinal dependence of high ozone concentrations. It shows how the curve $r_1 = 1 \times 10^{-6}$ descends above the greater part of the spring hemisphere, and descends slightly near the pole in the fall hemisphere. Higher O_3 concentrations are distributed more evenly at altitudes of 20-25 km above the entire globe. The region of highest concentrations above 8×10^{-6}, i.e., that of greatest ozone danger, is at an altitude of 29-37 km between latitudes of 40 and 0° in the gall hemisphere and 0 and 51° in the spring hemisphere. The decrease of the concentration in the middle stratosphere toward the pole is particularly noticeable in the fall hemisphere.

Let us now turn to the recurrence of large and small ozone concentrations in the lower stratosphere. We shall approximately evaluate the probability that an airplane will encounter a dangerous ozone concentration at any given level.

The only comparable quantitative material permitting an evaluation of this probability are systematic observations by means of ozone probes above Boulder (40° N, Colorado, U.S.A.) in 1963-1964. We selected from these data the values of ozone pressure p_3 at levels of 150 mb (13.6 km in terms of standard atmosphere) and 100 mb (16.25 km in terms of standard atmosphere) separately for the spring (March-May, when the ozone maximum is observed) and end of summer (July-September, when the total amount of ozone is lowest). Further, we calculated the weight concentration of ozone $r = 1.657 \frac{p_3}{p}$ and examined the frequency of our values from 0.1×10^{-6} to 2×10^{-6} at both levels (Fig. 3).

In the spring, the average value of r is 0.75 at the 150 mb level and $r = 1.0 \times 10^{-6}$ at the 100 mb level. At the 150 mb level, values r = 0.60-1.10 are repeated most frequently at that time (more than 50% of all the observations). A concentration greater than 1.0 is repeated in 25% of the cases. This means that at the 13.6 km level, the ozone concentration becomes "worrisome" in approximately one-fourth of all the flights, although it is still not harmful. The highest r values reached 2.3 on 3 and 25 March 1964, this value being close to toxic. These values, however, were noted only twice in 125 observations.

At the 100 mb level (16.25 km), the highest frequency was displayed by r values from 0.7 to 1.5, which accounted for 65 cases out of 127 (52%). This interval of the most probable values is appreciably shifted "upwards" in relation to that which was noted at the 150 mb level. The concentration was above $r_1 = 1.0$ in 74 cases (58%), i.e., it reached the "worrisome" threshold comparatively often. The highest r values (3.2 and 3.3) were also noted on 24 and 25 March 1964. The value of r was above 2.0 in 17 cases (13%).

Thus, an increase in flight altitude from 13.8 to 16.25 km is associated with both an appreciable increase in the most probable values and with an increase of the maximum r values.

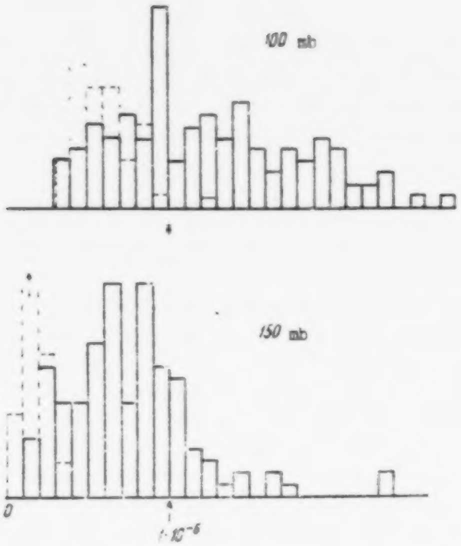

Fig. 3. Frequency of different ozone concentrations above Boulder U.S.A. at 150 and 100 mb levels in spring (solid lines) and summer (dashed lines). Arrow denotes value of concentration having a toxic effect.

In the summer above Boulder, the ozone concentrations at the levels considered are extremely low. The average concentration at the 150 mb level is around 0.19, and at the 100 mb level amounted to 0.37. The maxima of r do not exceed 0.7 and 1.25 respectively, and the ozone danger is practically nonexistent.

Let us also examine the data of soundings made in 1962-1963 at various points of North America. They are interesting in that they cover a broad range of latitudes, from the Panama Canal (9°N) to Thule (77°N). Of these values, we also selected (for comparison) the data for the 150 and 100 mb levels. The soundings of interest to us covered the period January-March 1963. An appreciable frequency was shown by higher r values only at the stations of Goose Bay (53°N), Fort Churchill (59°N), Eielson (Alaska, 65°N) and Thule (Greenland, 77°N). These are the points to which we will confine ourselves here. They give an idea of the latitudinal belt in which the dangerous phenomenon under consideration takes place.

Of the 22 cases of observations at all four points, the ozone concentration above $r = 2$ rose in 7 cases at the 150 mb level and in 21 cases at the 100 mb level. At the 100 mb level, the maximum r value reached 4.95 above Thule on 27 February 1963.

Let us note that in this series of observations the absolute maximum was 6.7×10^{-6} at an altitude of 17.8 km on 17 March 1968 above Fort Churchill. These values indicate a direct and great danger lurking in the arctic and subarctic zones for the crews and passengers of stratospheric airplanes. This calls for appropriate measures to purify the external air entering the plane.

A much more massive but also less graphic material is supplied by the reversal method; observations based on the latter are being conducted at many stations throughout the world. As we have noted above, these observations are coarser in the sense that they provide us only with information on the average ozone concentration in a large layer of 250-125 mb (10.3-14.8 km).

We first used data of the oldest station, Arosa (Switzerland), which had the longest series of observations at its disposal. The data published by this station, obtained by the reversal method, cover 1956-1964. We chose for these years all cases in which the average concentration (by weight) in the second layer was greater than 1 x 10^{-6}, by analogy with our previous standard. This corresponded to an average ozone pressure in the layer $\overline{p}_3 > 113$ μmb. Such cases were observed only from January to April. In the course of 8 years (1956-1959, 1961-1964), there were 58 of them out of 563 days of observations (10.3%), and the largest number of such cases was in February - 25 out of 127 days (19.7%).

The highest concentration in the second layer was observed on 14 March 1962, when $\overline{p}_3 = 185$ μmb, i.e., $r = 1.63$.

Among data of high latitude stations, we have only relatively short series of observations using the reversal method on Argentine Islands and Resolute. For the former, the available data pertain chiefly to the summer (17 out of 27 observations), i. e., to the season of lowest r values, and are therefore of no interest to us. The ozone concentrations here were generally very low. On Resolute, a relatively large number of observations were made in the spring, in April (20 out of 26), and systematically higher concentrations were observed. In April, r here is always greater than 1, and in one case as high as 1.84 ($p_3 = 207$ μmb). The volume of the material, however, is very slim and does not permit one to draw any other statistical conclusions.

In summarizing, it may be stated that in the lower stratosphere (up to 16-17 km), the probability of dangerous and even merely perceptible concentrations is nil in the belt from 0° to 40° latitude and increases only at higher latitudes in the winter and spring. At that time, they must be taken into account here when flights are made. Flights at higher levels will encounter a larger ozone content at all latitudes.

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IONIZATION OF ATMOSPHERIC AIR OF THE TOWN OF CHERVONOGRAD AND ITS SANITARY IMPORTANCE

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According to the data in the literature, the degree of ionization of atmospheric air depends on various environmental factors (A. A. Minkh, 1958; A. P. Sokolov, 1926; M. D. Kravchenko, 1939; A. P. Spasskiy, 1948; S. M. Chubinskiy, 1959; O. A. Voytsekhovskiy, 1959; M. S. Averkiyev, 1960; Yu. D. Dumanskiy, 1963, and others). The sanitary importance of the ionization of air is determined by its varied influence on the human organism. It has been shown that negative ions of air improve the blood composition, function of the nervous system, and working capacity, and are used in the treatment of many illnesses (V. G. Kunevich, 1934, 1955; V. M. Voskresenskiy, 1958; V. A. Titarenko, 1960; M. P. Davydova, 1959; Z. H. Shkulova, T. N. Pavlyuk, 1958; A. A. Kyuntsel', 1950; E. K. Siyrde, K. V. Gerasimova, A. K. Tsente, V. A. Syargova, 1959).*

The object of our studies was to investigate the ionization of atmospheric air in a town in connection with its pollution with emissions from boiler houses, mine pile-like waste dump, and apartment furnaces, in comparison with the outskirts of the town, where there are no industrial or domestic enterprises to pollute the atmospheric air.

Our study was also aimed at comparing the data obtained with meteorological factors.

The ionization of air was studied by using an SI-1 Tverskiy-Otto instrument with an SG-1M electrometer at stationary points: the central part of the town, mine I "Chervonogradskaya", the grounds of the bread factory, and the outskirts of the town in the area of a hospital center.

A total of 240 measurements were taken at the investigated points during the month of September 1968.

Results of the studies are given in the Table.

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* Editor's note: A bibliography does not accompany this paper.

Table

Ionization of Atmospheric Air of the Town of Chervonograd.

Point	Number of Ions in 1 cm^3 of Air								
	n+	n−	N+	N−	n±	N±	g	K	Q
Mine I "Chervonogradskaya" (industrial site)	363	325	4291	3990	688	8281	1,11	12,03	1,07
Waste dump of mine I "Chervonogradskaya" (distance from waste dump, 200 m)	264	224	6187	6229	488	12 416	1,17	25,44	0,90
Bread factory (boiler house)	238	208	7512	7448	446	14 960	1,14	33,31	1,00
Central part of town (residential blocks)	338	277	1237	1062	615	2299	1,22	3,73	1,10
Outskirts of town (hospital center)	552	524	1694	1569	1076	3263	1,05	2,10	1,07

It is evident from the table that light and heavy negative ions are somewhat less in number than positive ions at all of the points studied, the smallest number of ions being observed on the grounds of the bread factory and at the waste pile of mine I "Chervonogradskaya", this being due to a deterioration of the sanitary state of air caused by emissions from the boiler houses and the presence of the waste pile. Compared to the outskirts of the town, the quantity of light ions at the first four points is 1.5-2.4 times smaller. At the same time, the unipolarity coefficient is greater than unity and amounts to 1.11-1.22, whereas on the outskirts it is somewhat less, 1.05. It should be noted that the atmospheric air of the outskirts of the town is more ionized than in areas where smoke and gas pollution is observed.

Thus the prevalence of heavy ions over light ones as compared with the outskirts of the town is considerable and is an indication of atmospheric pollution.

The electric index of air purity on the outskirts of the town in the area of the hospital center is 2.10, and in the central part of the town, 3.73, whereas in the area of the bread factory, where emissions from the boiler house are present, it is 33.31, near the waste pile of mine I "Chervonogradskaya" 25.44, and at the mine site, 12.03.

The decrease in the quantity of light ions in the air of the town as compared with its outskirts substantially depends on the pollution of the atmosphere with dust and smoke and is due to an inadequate amount of greenery in the town sections. The small height of the stacks of the boiler rooms in these sections and the lack of gas and ash removal are responsible for the pollution of air with smoke discharges.

The pollution of the air of Chervonograd is also substantially due to house furnaces, which in 75% of the apartments consume solid fuel. According to our calculations, 2,655.8 tons of ash falls on the territory of Chervonograd each year, of which 2008.1 tons falls during the furnace season, when the dust pollution of atmospheric air varies from 0.79 to 1.35 mg/m^3.

Of the 1000 persons questioned, residing in Chervonograd, 100% complained of the presence of air pollution; 91.3%, of difficulty in aerating the apartments; and 100%, of laundry becoming dirty when dried in the yard

We also compared the ionization of atmospheric air with meteorological factors: temperature, hunidity, and barometric pressure. As the air temperature dropped from 20 to 15°C., a decrease in the concentration of ions was observed; as the humidity of air increased from 85 to 92%, the concentration of ions also decreased; a 5 mm decrease of barometric pressure led to an increase of the ions. The wind velocity did not produce any characteristic changes in the ion concentration, since the measurements of ions were carried out for a slight wind force, from 1.5 to 3 m/sec.

Similar results were obtained by O. A. Voytsekhovskiy (1959) and other authors.

The above studies of the ionization of atmospheric air of Chervonograd made it possible to develop and confirm a set of measures aimed at improving the conditions in the air reservoir for 1968-1970 and present them to executive agencies for adoption. These measures included: conversion of mine waste piles to flat piles, which are safer to operate and convenient for operations preventing their self-ignition, conversion of town boiler houses to gas, gasification of the town, gas-ash removal from mine boiler houses, creation of green zones between industrial enterprises and the town, additional enlargement of green plantings, and establishment of large and small parks taking into account the assortment of tree species that raise the natural ionization level. Plans are to provide the water reservoir in the town of Chervonograd with a water table area of no less than 7000 m^2, and there are a number of other measures to improve the layout of the town, some of which have already been implemented.

DETERMINATION OF LATENT TIME OF REFLEX REACTIONS OF LABORATORY ANIMALS ACTED UPON BY TOXIC AGENTS IN ATMOSPHERIC AIR

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At the present time, research in pharmacology, toxicology, physiology, sports medicine, labor hygiene, and communal hygiene (in studies of the microclimate) is making extensive use of the measurement of the latent time of reflex reactions as a highly sensitive indicator of the functional state of the nervous system, adequately reflecting its changes.

By latent time of reflex reactions is meant the time required for the conduction of stimulation along the reflex arc, consisting of a series of various morphological and functional elements: receptors, afferent nerves, nerve centers, efferent nerves, effectors.

Studies by Soviet and foreign authors established that although the magnitude of the latent reflex time is an integral indicator consisting of the time of conduction of the stimulation through all the component parts of the reflex arc, nevertheless the link in which the most important changes of its magnitude occur are the synapses of central neurons and their cell bodies.

It should be emphasized that this involves the determination of the functional state of various sections of the nervous systems at the instant of reproduction of the reflex arc of the entire act, which is a component part of many natural acts executed by the organism in the complex circumstances of life. In this sense, as was pointed out by S. I. Gorshkov (1962): "The latent time of a reflex reaction is much longer than that of chronaxy characterizing the functional state of any given tissue at the instant of its reproduction of a single stimulation wave, i. e., of an artificial product not found in natural life."

An accurate measurement of the latent time of a reflex reaction requires the observance of a series of conditions which include primarily the following: coincidence of the start of measurement of latent time with the instant of application of the stimulation; discontinuation of the operation of the counter at the instant of manifestation of the response reaction; the stimulus should appear instantaneously without a lag and not extend beyond the useful time. These requirements are met by the reflexogenometer proposed by S. I. Gorshkov (1964).

The procedure for the determination of the latent time of an unconditioned reflex reaction with this instrument consists in the following:

1) the rat is placed in a chamber; its extremities touch parallel metal plates, and the chamber lid supporting the counter switch rests on the back of the animal;

2) the time scan of the instrument is turned on (1 rps);

3) the threshold intensity of the pulsed current that constitutes the unconditioned electrocutaneous stimulus is selected. At the threshold current intensity, the rat is startled, causing the switch on the chamber lid to close and the operation of the counter to stop;

4) the time elapsed from the instant of application of the stimulation (position of the sliding contact) until the indicator of the counter comes to rest (determined from the scale of the instrument) will be the latent time of the defensive unconditioned reflex reaction expressed in sigmas.

Five measurements were carried out in a single series of experiments. In order to avoid trace phenomena, the interval between them was made to last 2-3 minutes. The slight scatter of the data obtained is quite regular and constitutes in itself a functional characteristic of the state of the central nervous system. The arithmetic average of all the measurements is the latent time of the defensive unconditioned reflex reaction. Since the current intensity of the painful stimulus affects the latent reaction time, this intensity must be the threshold value and must not be changed in a single series of experiments (five measurements).

The results of the study were recorded in the following manner (Table 1).

Studies of the change in the latent time of the defensive unconditioned reflex reaction were made once a week at the same hour on five rats of each group. The results obtained were processed by variational statistics, sigma being found by the range method.

In the laboratory of the department of Sanitary Protection of Atmospheric Air, Moscow Scientific Research Institute im. F. F. Erisman, the variations of the latent time of the unconditioned reflex reaction in white rats were studied by subjecting the animals to chronic exposure in vapors of α-methylstyrene, epichlorohydrin, and ammonia, and to the combined action of phenol and sulfur dioxide. The active concentrations were found to be 5.0 mg/m^3 for α-methylstyrene, 20.0 mg/m^3 for epichlorohydrin, 20 mg/m^3 for ammonia, and for the combined action, 0.05 mg/m^3 for phenol and 0.5 mg/m^3 for sulfur dioxide.

The observed variations of the functional state of the central nervous system in the animals under the influence of chronic inhalation of the toxic substances present in atmospheric air were confirmed by changes in the activity of cholinesterase and in the content of nucleic acids in the blood, an impairment of the excretion of coproporphyrin with the urine, and pathomorphologic changes in the central nervous system.

Table 1.

(Control group).

Date	No. of rat	Current intensity in U	Latent reflex time in sigmas.						
			1	2	3	4	5		M
12. III	1	20	40	45	48	40	39	212	42,4
	2	20	40	45	40	48	50	218	43,6
	3	25	45	43	50	44	40	222	44,4
	4	18	48	40	36	46	34	204	40,8
	5	18	48	45	50	35	45	223	44,6

Thus, our studies and the results obtained make it possible to recommend the method of determination of the latent time of the defensive unconditioned reflex reaction for use in the sanitary standardization of toxic substances in atmospheric air.

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METABOLIC REACTIONS IN THE ORGANISM IN THE PRESENCE OF CHRONIC INTOXICATION WITH CARBON MONOXIDE

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From Ministerstvo Zdravookhraneniya Ukr.SSR, L'vovskiy Nauchno-Issledovatel'skiy Institut Epidemiologii i Mikrobiologii. "Faktory vneshney sredy i ikh znachenie dlya zdorov'ya naseleniya". Respublikanskiy mezhvedomstvennyy sbornik. Vypusk 2. "Zdorov'ya", Kiev, p. 146-149, (1970).

Chronic carbon monoxide intoxication as an independent nosological disease form, manifested as a highly polymorphous set of symptoms, requires a further elucidation of the fine mechanisms of its generation. Shifts in the organism that are difficult to account for are sometimes ascribed to the unknown area of cellular metabolism impaired by the direct action of carbon monoxide. Histochemical studies have successfully shown that even negligibly low carbon monoxide concentrations in the inhaled air are capable of altering the stages of normally occurring metabolic processes in the organism. This applies primarily to the principal types of metabolism, i.e., the protein, fat and carbohydrate types.

The earliest changes in carbon monoxide intoxication are observed in the content of fatty substances in the brain tissue. An increase in fatty substances stained with sudan black (phospholipids) and according to Jackson (total fat content) was particularly manifest in the cerebral cortex. In the cerebellum, lipid increase was chiefly concentrated in white matter. Purkinje cells underwent a considerable increase in lipids. A pattern of substantial increase in the content of fatty substances was also characteristic of the tissues of the myocardium, liver, kidneys, and adrenal glands (I. I. Datsenko, N. S. Dotsenko, V. Z. Martynyuk, and Ye. I. Pal'chevskiy, 1965).* Changes were observed histochemically in the carbohydrate and protein metabolisms, but they were less pronounced than changes in lipids.

Analysis of results of these studies led to the corollary question, closely related to fat metabolism and playing a predominant part in the pathogenesis of atherosclerosis, of the quantitative content of cholesterol in the blood in the presence of chronic intoxication with carbon monoxide. This question is the subject of the present paper.

The total cholesterol was determined by the Mrskos-Tovarek method (Y. Todorov, "Clinical Laboratory Studies in Pediatrics", Sofia, 1963). The method is based on the principle of the appearance of an emerald color in the reaction of cholesterol with acetic anhydride. The hematological indices were determined by the standard procedure.

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* Editor's note: A bibliography does not accompany this paper.

Table 1

Blood Picture of White Rats and Guinea Pigs
Under Conditions of Chronic Carbon Monoxide Intoxication

Group of Animals	Series of Experiments	Number of Blood Tests	Average Values of Indices								
			Hemoglobin, %	Erythrocytes per 1 mm^3 of Blood	Leukocytes	Segments	Lymphocytes	Monocytes	Eosinophils	Staff Cells	ESR in mm/hr
Experimental White Rats	I	15	90	8 319 000	13 323	23,5	74	2	1	1	5,5
Control White Rats		15	89	7 631 000	15 589	26	74	1	1	1	4,6
Experimental White Rats	II	30	89	6 859 000	11 873	23	73	2	2	1	7,0
Control White Rats		28	90	7 550 000	12 238	20	77	1	1	1	5,0
Experimental White Rats	III	10	91	6 589 000	14 175	22	72	2	1	2	4,4
Control White Rats		10	97	7 530 000	15 280	24	69	4	1	1	7,0
Experimental Guinea Pigs	II	5	97	6 762 000	15 541	17	75	1	1	1	5,0
Control Guinea Pigs		5	98	7 100 000	15 650	28	65	1	1	1	5,0

The animals were exposed in an exposure chamber into which was introduced carbon monoxide prepared by the action of heated concentrated sulfuric acid on concentrated formic acid. The carbon monoxide concentration in the exposure chamber, calculated for each series of experiments, was systematically checked by the Reberg-Vinokurov method.

A total of 40 animals were used in the chronic experiments.

The experimental animals (15 white rats) were subjected to a chronic five-hour daily exposure to carbon monoxide present in a concentration of 0.009-0.018 mg/l in the air of the chamber, in the course of 1.5 months (series I of experiments), then to a concentration of 0.030-0.040 mg/l for another 3 months (series II of experiments)* and finally to a concentration of 0.080-0.100 mg/l for 1 month (series III of experiments). Fifteen white rats served as the control. Five experimental guinea pigs were subjected to chronic daily exposure to carbon monoxide at a concentration of 0.030-0.040 mg/l in the air of the chamber for 1.5 months. Five guinea pigs served as the control.

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* In series II of experiments, all the biochemical indices were determined twice, after 1.5 months and after 3 months of exposure.

Results of the hematological indices are given in Table 1.

As is evident from the above data, the amounts of hemoglobin, erythrocytes and leucocytes and also the differential white count indices in the experimental animals do not differ appreciably from those of the control white rats and guinea pigs.

In contrast, studies of the total blood cholesterol showed statistically significant differences between the control and experimental animals in each series of experiments (Table 2).

Table 2

Changes in the Amounts of Total Cholesterol in the Blood of Rats in the Presence of Chronic Carbon Monoxide Intoxication

Group of Animals	Average Values of Cholesterol (in mg %)					
	Series I. CO Concentration 0.009-0.018 mg/l		Series II. CO Concentration 0.030-0.040 mg/l		Series III. CO Concentration 0.080-0.100 mg/l	
	n	$\bar{x} \pm S_{\bar{x}}$	n	$\bar{x} \pm S_{\bar{x}}$	n	$\bar{x} \pm S_{\bar{x}}$
Experimental White Rats	11	196 ± 2,70	21	180 ± 2,51	9	176 ± 2.08
Control White Rats	13	180 ± 2,94	22	167 ± 2,33	9	169 ± 2,21
t		4,01		3,80		2,30
P		< 0,01		< 0,01		< 0,05

Average values of total cholesterol in the blood of experimental guinea pigs are also higher than in the controls, and amount to 163 ± 2.65 versus 153 ± 2.68 mg % ($P < 0.05$).

Hence, hyperlipemia is observed at the earliest stages of poisoning under the influence of minute carbon monoxide concentrations. A similar difference was noted in the second and third series of experiments.

Thus, the data obtained on the cholesterol content of the blood and also the presence of carboxyhemoglobin in the blood of the experimental animals attest to the change in the metabolic processes in the organism in the presence of chronic carbon monoxide intoxication. They are in agreement with and supplement the results of histochemical studies and permit one to postulate a considerable influence of carbon monoxide on the development of atherosclerotic symptoms in the organism. Consideration of the latter fact should be mandatory in the diagnosis of cardiovascular disease by clinicians.

DATA FOR SUBSTANTIATING MAXIMUM PERMISSIBLE CONCENTRATIONS OF ELEMENTAL SULFUR DUST IN THE AIR OF INDUSTRIAL BUILDINGS

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Sulfur dust as an industrial impurity has not been studied by anyone, and according to sanitary legislation (SN245-63) belongs to the category of nontoxic dusts.

The object of the present study was to investigate the biological effect of elemental sulfur dust on the organism of experimental animals in order to substantiate its maximum permissible concentration in the air of industrial buildings.

Studies of the toxic action of sulfur dust in a chronic experiment were conducted on 86 male white rats with an initial weight of 160-200 g. Exposure of animals in the experimental groups was carried out in a dust chamber in the course of 4.5 months, 3.5 hours a day. The inhalational exposure of the animals involved the use of industrial dust of sulfur ore containing 48% of elemental sulfur, and also dust of pure elemental sulfur. The amounts of dust inhaled by the animals were recalculated in terms of pure sulfur.

The animals in the experiment were divided into 7 groups - four experimental and three control groups. The first experimental group was exposed to sulfur ore dust in a concentration (in terms of pure sulfur) of 4.5 mg/m^3 of air, and the second and third, to 11.2 and 30.8 mg/m^3 respectively. The fourth experimental group of white rats was subjected to inhalational exposure to dust of pure elemtnal sulfur in a concentration of 8.6 mg/m^3.

In all the animals, the morphological composition of the blood, the activity of the blood enzymes, catalyse and peroxidase, and also the content of sulfhydryl groups and sugar in the blood were investigated under dynamic conditions. The weight increase and behavior of the animals were taken into account. The studies were made before the start of exposure (background) and at definite times following the start of the experiment (first, second, third months of exposure), and also after the experiment was completed. In addition, after the completion of exposure, the ascorbic acid content of the vital organs was determined in rats of the second group, exposed to sulfur dust in the concentration of 11.2 mg/m^3 of air.

As was shown by the results of the observations, a statistically significant 43.0% decrease in weight gain took place only in animals of experimental group III, subjected to the chronic action of elemental sulfur dust in a concentration of 30.8 mg/m^3, as compared with the control group. In rats of experimental groups which received lower doses of sulfur, the weight gain was no different from that of the controls.

In view of the fact that when sulfur enters through the respiratory tract it may react in the alveoli with free SH groups of the blood, we undertook a study of these groups in the blood of the experimental animals.

In animals that received sulfur in the concentration of 11.2 mg/m^3 of air, a 10.7% decrease in the content of SH groups (P = 98.9) was noted in the third month of exposure. A statistically significant decrease in the content of sulfhydryl groups in the blood in the second and third months of the experiment was also observed in animals which received sulfur in the dose of 8.6 mg/m^3, but toward the end of the experiment their content returned to normal, apparently as a result of adaptation. In rats subjected to inhalational exposure in the dose of 30.8 mg/m^3, the content of sulfhydryl groups of the blood decreased by 12.8-20.5% in the course of the entire period of exposure. In rats of the control groups and animals exposed to sulfur dust in the concentration of 4.5 mg/m^3, no changes occurred in the content of sulfhydryl groups in the blood.

Thus, sulfur in doses of 8.6, 11.2 and 30.8 mg/m^3 of air, when it penetrates via the respiratory tract, leads to a 10.7-20.5% decrease in sulfhydryl groups of the blood of white rats, this being in agreement with the literature data regarding the mechanism of conversion of sulfur in the organism.

As we know, hydrogen sulfide exerts a general toxic action by depressing the tissue respiration enzymes. This is associated with effects of hypoxia in the tissues and with an impairment of the oxidation-reduction processes. Hydrogen sulfide is an inhibitor of many enzymes, including catalase and peroxidase (M. Dikson and E. Webb, 1961).*

We undertook a study of the activity of the above-mentioned enzymes in the blood of experimental white rats exposed to sulfur dust.

It was found that in animals that received sulfur in doses of 11.2 and 8.6 mg/m^3 of air, a statistically significant 12.3-12.9% decrease in peroxidase activity of the blood took place starting with the second month of exposure and lasting until the end of the experiment. In rats exposed to sulfur dust in the 30.8 mg/m^3 concentration, a 13.1% depression of peroxidase activity was observed as early as the first month of the experiment; in the third month and following completion of the experiment, this decrease amounted to 14.2 and 13.0% respectively (P = 97.1 and 98.9%). A tendency toward a decrease in the peroxidase activity of the blood was noted in rats exposed to sulfur dust in the concentration of 4.5 mg/m^3 of air. The activity of blood peroxidase of the animal control groups did not decrease. No appreciable changes were detected in the activity of blood catalase in the experimental animals. The observed depression of peroxidase activity of the blood in experimental animals may indicate a disturbance of oxidation processes in the organism.

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* Editor's note: A bibliography does not accompany this paper.

According to the data of Ya. R. Volynskiy (1947), hydrogen sulfide poisoning causes an increase in the content of vitamin C in the vital organs as a result of a disturbance of oxidation processes. Studies which we undertook in this direction, conducted on rats subjected to inhalational exposure to sulfur dust in the 11.2 mg/m^3 concentration, did not reveal any substantial changes in the vitamin C content of the tissues.

In connection with reports published in the literature concerning changes in blood proteins among workers employed in the sulfur industry (G. Paparopoli, 1955; V. Gramignani, 1959), we undertook studies of the content of total protein and its fractions in the blood serum of experimental animals.

Results of the studies established that in rats exposed to sulfur dust in doses of 8.6, 11.2 and 30.8 mg/m^3 there was only a slight increase in the content of total protein, 4.5-8.1%, as compared with the control group. A study of the protein fractions showed the presence of hypoalbuminemia (up to 25.0%) as a result of a statistically significant increase of the globulin fractions, chiefly α_3- (up to 40.0%) and β fractions. The data obtained indicate a disturbance of protein synthesis in the liver.

On the basis of earlier studies of the working conditions among workers of a sulfur plant (L. I. Brilinskiy, 1963) and results of the present experimental studies it may be concluded that a sulfur dust concentration of 10 mg/m^3 of air, which at the present time is permitted by legislation as the maximum permissible concentration, is not harmless to the organism of the workers and should be decreased; a maximum permissible concentration of elemental sulfur dust in the air of industrial buildings at a level of 2 mg/m^3 can be recommended.

HYGIENIC EVALUATION OF ATMOSPHERIC POLLUTION BY DISCHARGES OF A SULFUR-PRODUCING CHEMICAL-MINING COMPLEX

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The Rozdol'skiy chemical-mining complex, one of the largest sulfur-producing enterprises in the world, operates in the Carpathian region, using its rich deposits of natural sulfur.

The literature has lacked data on atmospheric pollution by enterprises producing lump sulfur and on the possible influence of atmospheric pollution on the population living in the zone of such enterprises. Sanitary norms SN 245-63 for designing industrial enterprises do not specify the width of the sanitary protective zone for such industry.

In this connection, studies described in the present report were carried out by the Hygiene Department of the L'vov Institute of Epidemiology and Microbiology. Results of the study of atmospheric pollution by discharges of the Rozdol'skiy sulfur-producing chemical-mining complex (903 analyses) are given in the table.

Gas Pollution of Atmospheric Air in the Zone at the Sulfur-Producing Chemical-Mining Complex (mg/m^3)

distance from source of discharges in m	hydrogen sulfide concentration		sulfur dioxide concentration	
	maximum	average $(\bar{x} \pm S\bar{x})$	maximum	average $(\bar{x} \mp S\bar{x})$
100	10,700	1,124±0,355	1,80	0,140±0,049
250	2,480	0,265±0,106	0,34	0,115±0,040
500	1,160	0,107±0,040	0,23	0,062±0,018
1000	0,600	0,162±0,025	0,35	0,148±0,026
2000	0,290	0,037±0,004	0,35	0,029±0,008
3000	0,012	0,004±0,0002	—	—
5000	0,002	0,001±0,0001	—	—
7000	0	0	0,36	0,050±0,020

A distinct zonality of the propagation of air pollutants was observed. As the distance from the combine increased, the hydrogen sulfide content decreased, but at a distance of 1000 m from the source of discharges, its maximum single and average concentrations exceeded the permissible level for the atmospheric air of populated areas.

In the atmospheric air of the residential zone (2000 m from the plant complex), the average hydrogen sulfide content was 4.6 times the maximum permissible concentration; the maximum single values reached 0.209-0.290 mg/m^3 at high wind velocities (9.6-12.4 m/sec) of western and southwestern directions. At distances of 3000 and 5000 m from the plant complex, the amount of hydrogen sulfide did not exceed the permissible level. No hydrogen sulfide was observed in atmospheric air at a distance of 7000 m.

The average and maximum single concentrations of hydrogen sulfide in atmospheric air at distances exceeding 700 m were below the permissible level. Kerosene vapor was observed in the range of 100-250 m in amounts of 0.87 ± 0.23 and 0.79 - 0.25 mg/m^3. Both concentrations in atmospheric air, found at various distances from the plant complex, exceeded the maximum permissible value by a factor of 1.5-7.5.

Consequently, the existing 2000 m gap between the complex and the residential zone must be considered insufficient for discharging gases into the atmosphere without purification.

The spreading of atmospheric pollutants including hydrogen sulfide at distances of 2000-4000 m from industrial facilities was pointed out by E. S. Turetskaya (1947, 1959), D. N. Kalyuzhnyy, L. M. Volova, E. S. Turetskaya (1948), N. Ya. Yanysheva (1955), R. A. Loginova (1957), K. K. Kiyamov (1960), D. N. Kalyuzhnyy, and I. S. Kireyeva (1964). For this reason, it appeared necessary to study the possible influence of atmospheric pollutants on the population.

The social-economic and medical-geographic conditions at two populated points of the zone of the plant complex and at a populated point located at a distance of 7000 m from the complex were identical and, since no hydrogen sulfide was observed in the air of this zone, this air was taken as the control.

The questioning of 1500 adults (one in every apartment) was carried out in accordance with a specially prepared inquiry based on a questionaire supplied by the Kiev Institute of General and Communal Hygiene. The age and sex composition of the population questioned was approximately the same at the points compared (men 48.8-57.2%, women 42.8-51.2%; age 21-40 years). The residence time was 4.7 years. The persons questioned in the zone of the complex periodically smell hydrogen sulfide to a greater (69.2-76.8%) or lesser (23.2-30.6%) degree, which is much more frequent than at the control point (1.0 and 56.0%). It is frequently impossible to aerate the apartments in the zone of the complex because of the strong hydrogen sulfide odor (70-79% of those questioned in the zone of the plant complex and 1.8% at the control point). The population in the zone of the complex complained of headache, dizziness, and rapid fatigue 4.1-4.7 times more frequently than at the control point. Burning eyes and an unpleasant taste in the mouth were noted 13.1-28.8 times more frequently in the zone of the complex than outside it. Complaints of frequent colds were voiced by 7 and 5% of persons living near the plant complex, and by 1.8% at the control point.

A statistical treatment of the disease rate (5726 outpatient clinic registration cards) revealed a higher level of incidence of conjunctivitis, diseases of the respiratory tract and ear, nose, and throat diseases in children living in the zone of the plant complex. An anthropometric survey of random groups of practically healthy children of younger school age established a fully satisfactory physical development of children in the zone of the complex and in the control point: the indices of growth, weight, and vital capacity of the lungs corresponded to contemporary age standards (statistical annual "National Economy of the USSR in 1960"). In a selective investigation of the changes in the x-ray picture of the lungs* (changes in the roots of the lungs in the presence of indurated or petrified lymph nodes) and in the morphological picture of the blood (moderate erythropenia, low hemoglobin level, slight leucopenia, monocytosis) of children living in the zone of the plant complex were recorded more frequently than at the control point.

Statistics of the disease rate of the adult population not employed by such an enterprise (9832 clinic registration cards) revealed a higher disease rate among inhabitants of the zone of the complex, involving conjunctivitis, ears, nose and throat diseases, and diseases of the nervous system. Changes in the x-ray picture of the lungs (reinforcement of the lung pattern, increased density of the lungs, and dilation of the roots of the lungs) and in the morphological composition of the blood (moderate erythropenia, somewhat decreased hemoglobin level, slight leucopenia as a result of neutropenia with relative monocytosis, lymphocytosis) in the population of the zone of the plant complex were found more frequently than at the control point.

The observed differences in the state of health of the population in the zone of the complex and at the control point apparently should be attributed to a decrease of the resistance of the body under polluted air conditions. Our data on the influence of discharges of the chemical-mining plant on the sanitary living conditions and health of the population are in agreement with the data of R. A. Babayants (1949), N. M. Tomson (1952), D. N. Kalyuzhnyy (1954, 1961), M. S. Gol'dberg (1957), Z. Ya. Lindberg (1960), M. L. Krasovitskaya (1965), H. L. Motley, R. H. Smart, C. I. Leftwich (1959), Vaclav Picko (1962), and J. R. Goldsmith (1964), who showed the undesirable effects of atmospheric pollutants on the population.

Under natural conditions, it is difficult to evaluate the isolated effect of any given factor on the population. It was therefore of interest to make an experimental microtoxicological study of the effect of hydrogen sulfide and sulfur dioxide thrown into the atmosphere with the discharges of the complex

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*The x-ray study was made by radiologist V. V. Danileychenko.

(continuous inhalation effect in the course of 45 days). The studies were made on 112 male rats.

The hydrogen sulfide - sulfur dioxide complex in a concentration of 0.0085 ± 0.00012 and 0.570 ± 0.180 mg/m^3 respectively was found to have an influence on the body. Changes in conditioned reflex activity were observed in the animals (lengthening of the period of formation and fixation of positive conditioned reflexes to stimulants of various intensities, increase of latent periods of conditioned reactions, frequency of phase states), 40% decrease in the activity of blood cholinesterase, 41% decrease in phagocytic capacity and change in the luminescent properties of leucocytes, 39.8% decrease in the number of sulfhydryl groups in the blood, increase in the amount of fat and decrease in the amount of glycogen in the liver. Lower concentrations of the hydrogen sulfide - sulfur dioxide complex had no effect on the bodies of experimental animals.

Consequently, on the basis of the above experimental data, it may be stated that the joint presence of hydrogen sulfide and sulfur dioxide in the atmosphere in the concentrations studied is not permissible from a hygienic point of view.

On the basis of a comprehensive evaluation of the results of natural and experimental studies, it was concluded that hydrogen sulfide must be removed from discharges of the plant complex into the atmosphere. A gas purification shop was built during the fourth quarter of 1966 and set in operation in the second quarter of 1967. The effectiveness of operation of the gas purification equipment is being studied.

BIOLOGICAL EFFECT OF SULFUR DIOXIDE AND PHENOL IN COMBINATION ON THE HUMAN AND ANIMAL ORGANISM UNDER EXPERIMENTAL CONDITIONS

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From Ministerstvo Zdravoochraneniya RSFSR. Moskovskiy Nauchno-Issledovatel'skiy Institut Gigieny Im. F. F. Erismana. "Voprosy gigieny atmosfernogo vozkukha i planirovki naselennykh mest". Uchenye zapiski, Moskva, p. 57-61, (1968).

According to literature data, the toxic effect of sulfur dioxide and phenol has been studied mainly in high concentrations (N. V. Lazarev, I. V. Sidorenkov, L. S. Rozanov, Z. E. Grigor'yev, Greenwald, W. B. Deichmann, K. F. Kitzmiller, Weitherup, etc.).

The biological effect of low concentrations of sulfur dioxide and phenol was first studied by F. I. Dubrovskaya (1957), B. Mukhitov (1963), and K. A. Bushtuyeva (1964).

Our objective was to study the biological effect of these substances in combination.

The determination of the odor threshold was made by using a procedure recommended by the Committee on Protection of Atmospheric Air (V. A. Ryazanov, K. A. Bushtuyeva, and Yu. V. Novikov, 1957).

The odor threshold for sulfur dioxide was determined on 19 subjects.

Tests of sulfur dioxide were carried out in concentrations ranging from 3.2 to 0.22 mg/m^3. Data on the determination of the odor perception threshold of sulfur dioxide showed that ten persons out of nineteen perceived the odor of sulfur dioxide in a concentration of 0.88-0.87 mg/m^3, which is below the odor threshold determined by F. I. Dubrovskaya (1957) and K. A. Bushtuyeva (1964).

The odor perception threshold of phenol was determined for the same 19 subjects. A concentration of 0.022 mg/m^3 was found to be the minimum perceptible value, and 0.016 mg/m^3 was the maximum imperceptibel value, i.e., our data confirmed the results obtained by B. M. Mukhitov (1963).

The odor threshold in the combined presence of sulfur dioxide and phenol was then determined on the same 19 subjects. The perception threshold of sulfur dioxide and phenol (in combination) for the most sensitive persons (5 out of 19) was 0.44 mg/m^3 for sulfur dioxide and 0.011 mg/m^3 for phenol, in two subjects 0.33 mg/m^3 (sulfur dioxide) and 0.011 mg/m^3 (phenol), while a sulfur dioxide concentration of 0.22 mg/m^3 and phenol concentration of 0.005 mg/m^3 were found to be imperceptible for them.

Adaptometric observations were made on three subjects. Three combinations of the substances studied were investigated. In all the subjects, the sulfur dioxide and phenol concentrations, equal to 0.88-0.22 mg/m^3 and 0.44-0.011 mg/m^3 respectively, caused a statistically significant change in light sensitivity, whereas concentrations of 0.22 mg/m^3 of sulfur dioxide and 0.005 mg/m^3 of phenol proved to be inactive when treated statistically.

Encephalographic studies were carried out on four subjects by using the procedure of A. D. Semenenko (1963). The potentials of the cerebral cortex were taken off by the bipolar method and recorded with a four-channel ink-recording encephalograph of domestic manufacture. The treatment of data included values of the total activity of the potentials of the cortex in response to synchronous stimulation with sound and light lasting from 6 to 20 seconds. A total of 82 electro-encephalograms were recorded. Concentrations taken in the ratio of 0.44 mg/m^3 of sulfur dioxide to 0.011 mg/m^3 of phenol caused a statistically significant change in the electric activity of the cortex in all four subjects. A concentration ratio of 0.22 mg/m^3 of sulfur dioxide to 0.005 mg/m^3 of phenol was found to be inactive.

Considering that in our studies the threshold odor concentrations for the most sensitive persons coincided with those established earlier for phenol only, and that we did not determine the isolated action of sulfur dioxide and phenol by means of adaptometry and encephalography, the effect of combined action of the substances studied was determined from the odor threshold as the most sensitive test. Calculation showed that the effect is close to a simple summation

$$\frac{0.33}{0.87}\text{ sulfur dioxide } + \frac{0.022}{0.011}\text{ phenol} - 0.87.$$

In order to refine the inactive concentrations of sulfur dioxide and phenol (in combination), the subthreshold concentrations were studied (0.22 mg/m^3 of sulfur dioxide and 0.005 mg/m^3 of phenol), whose fractions of their highest single maximum permissible concentrations add up to less than unity. As shown by all the methods used, these ratios did not cause any statistically significant changes in the physiological reactions of the organism. For this reason, the highest single maximum permissible concentrations of sulfur dioxide jointly present with phenol which are recommended are such concentration ratios of these substances for which the sum of the fractions of their highest single maximum permissible levels does not exceed unity.

In order to bring out the minimum functional shifts in the organism of animals as a result of a prolonged action of combinations of sulfur dioxide and phenol, a three-month round-the-clock dynamic exposure of white rats was carried out. Sixty females were selected for the exposure and divided into four equal groups.

The rats of the first group were exposed to 1.43 ± 0.2012 mg/m^3 of sulfur dioxide and 0.49 ± 0.00488 mg/m^3 of phenol, those of the second group to 0.45 ± 0.011168 mg/m^3 of sulfur dioxide and 0.0493 ± 0.00112 mg/m^3 of phenol, and those of the third group to 0.046 ± 0.000928 mg/m^3 of sulfur dioxide and 0.0051 ± 0.000058 mg/m^3 of phenol; the fourth group was the control.

The completion of exposure was followed by a recovery period. All the data were processed statistically by the range method.

During the entire period of exposure, no changes were observed in the general state or behavior of the animals. The rats were equally active in all the chambers, ate well, and gained weight regularly. No significant weight changes were observed in any of the animals as compared with the control.

In order to evaluate the chronic effect of sulfur dioxide and phenol concentrations (in combination), we studied the coproporphyrin metabolism (M. I. Gusev and Yu. K. Smirnov, 1960).

Results of the studies showed that shifts were produced in rats of groups I and II in the direction of a decrease in the excretion of coproporphyrin with the urine on the 20th day of exposure. After ten days of the recovery period, the porphyrin metabolism of rats of these groups returned to normal. In rats of groups III-IV, no appreciable change was observed in the porphyrin metabolism.

A study of cholinesterase activity showed that in rats of groups I-II as compared with the control, a depression of the activity of this enzyme was observed, indicating an impairment of the compensatory functions of the organism.

Examination of a series of hematological indicators revealed a statistically significant increase in leucocytes with orange fluorescence.* As a result of the toxic effect of sulfur dioxide and phenol on the physicochemical exchange of leucocyte cells, an orange fluorescence of the leucocytes was observed in rats of groups I-II. A particularly noticeable increase in the number of cells with altered fluorescence was observed during the first period of exposure. No changes could be found in the other blood indicators (resistance of erythrocytes, hemoglobin). Nucleic acids also failed to show any significant shifts.

One of the sensitive tests was found to be the latent reflex time indicator. The latent time was measured with S. I. Gorshkov's reflexogenometer (1963). During the period of exposure, the tests were conducted once every ten days. The latent reflex time was determined from the speed with which the motor response occurred. As a result of the toxic action of the substances studied in animals of chambers I and II, a shortening of the latent reflex time was observed, indicating a predominance of stimulation processes in the central nervous system.

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*Editor's note: For the Russian terms "luminescent" and "luminescence" in this paper we have substituted "fluorescent" and "fluorescence" on the basis of the definitions of these terms.

Pathologico-anatomic autopsies followed by microscopic examinations of the internal organs and central nervous system of rats in group I showed slight indications of interstitial pneumonia, degenerative changes in the kidneys, and a decrease in the glycogen function of the liver. Primary irritations of the large neurons of the cortex and brain stem were observed in the central nervous system. In rats of group II, these changes were variable and slight. No changes could be detected in rats of groups III and IV.

Thus, the results of the chronic experiment make it possible to recommend the following concentrations of the substances studied in combination: sulfur dioxide 0.05 mg/m^3 and phenol 0.005 mg/m^3, which gave no statistically significant shifts in any of the tests.

However, considering that the combined effect of sulfur dioxide and phenol is close to a simple summation, the mean daily maximum permissible concentrations which can be recommended are any combinations of these substances which, when divided by the mean daily maximum permissible concentrations for isolated action, add up to not more than unity.

Data of the completed experimental studies aimed at a sanitary substantiation of the highest single and mean daily maximum permissible concentrations for sulfur dioxide and phenol (in combination) have been approved and endorsed by the section on sanitary protection of atmospheric air of the Problem Commission of the Academy of Medical Sciences of the USSR in connection with the related problem of the "Biological Effect and Sanitary Importance of Environmental Factors in Populated Areas", and were conveyed to the Ministry of Public Health of the USSR for ratification as legal standards.

Conclusions

1. The threshold of olfactory perception of sulfur dioxide for the most sensitive persons is 0.87 mg/m^3, and for phenol, 0.022 mg/m^3. For combined action, it is 0.33 mg/m^3 for sulfur dioxide and 0.011 mg/m^3 for phenol. The threshold of action on the light sensitivity of the dark-adapted eye and electric activity of the brain was the following ratio: 0.44 mg/m^3 of sulfur dioxide to 0.011 mg/m^3 of phenol. These two tests showed the following concentrations to be inactive: 0.22 mg/m^3 for sulfur dioxide to 0.005 mg/m^3 for phenol. The combined effect of this interaction is close to a simple summation.

2. When sulfur dioxide and phenol are jointly present in atmospheric air,

their total highest single concentration expressed in fractions of the maximum permissible value for each of them in isolated action should not exceed unity.

3. A study of the resorptive effect of low concentrations of sulfur dioxide in combination with phenol on the organism of white rats under conditions of a three-month round-the-clock inhalational exposure showed that concentrations of 1.5 and 0.5 mg/m^3 of sulfur dioxide present together with 0.5 and 0.05 mg/m^3 of phenol respectively cause statistically significant shifts in the direction of a decrease in the excretion of coproporphyrin with the urine, depression of cholinesterase activity, increase in the number of leucocytes with altered cell fluorescence, shortening of the latent reflex time, and also pathomorphologic changes in the lungs, heart, liver, kidneys, and brain. Concentrations of 0.05 mg/m^3 of sulfur dioxide and 0.005 mg/m^3 of phenol proved to be inactive.

4. The mean daily maximum permissible concentration of sulfur dioxide and phenol jointly present in atmospheric air, expressed in fractions of mean daily maximum permissible concentrations for isolated action, whould not exceed unity.

EFFECT OF LOW CONCENTRATIONS OF α-METHYLSTYRENE VAPOR ON THE HUMAN ORGANISM

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From Ministerstvo Zdravoochraneniya RSFSR. Moskovskiy Nauchno-Issledovatel'skiy Institut Gigieny Im. F. F. Erismana. "Voprosy gigieny atmosfernogo vozdukha i planirovki naselennykh mest". Uchenye zapiski, Moskva, p. 42-49, (1968).

The resolutions of the 13th congress and the Program of the CPSU adopted by it stated the objective of creating the material and technological base of Communism.

The development of the chemical industry assumes an exceptional importance in the fulfilment of this objective, since the use of chemical products and synthetic materials will permit radical qualitative changes in key areas of production of consumer goods.

The growth of the production output of synthetic rubber at the end of 1965 had increased 3.4 fold over the year 1957, and the synthetic rubber industry will be completely converted from the use of the feed stock employed earlier to economically more advantageous raw materials: petroleum, natural gas, and associated gases of petroleum production and refining (Plenum of the Central Committee of the CPSU, May 1958).

A rapid development of the chemical industry will unquestionably result in the contamination of the environment with a large quantity of various substances posing danger to man.

For this reason, the object of sanitary science and in particular atmospheric hygiene is the establishment of recommendations for maximum permissible concentrations of these substances, for the purpose of preventing their harmful effect on man and his environment.

In 1962, we carried out a study of atmospheric pollution around a new plant producing divinyl-methylstyrene synthetic rubber from associated gases of petroleum production and refining as the raw materials.

A total of 323 air samples to be analyzed for α-methylstyrene and 270 air samples for unsaturated hydrocarbons were collected.

The air samples were taken at a height of 1.5 m above ground at the plant site and in eight zones at distances from 500 to 5000 m on the leeward side of the plant.

During the collection of air samples, the odor of gases was clearly perceived in zones up to 1500 m, and on some days even up to 2000 m from the plant.

The results obtained (Table 1) showed that the heaviest pollution of atmospheric air with α-methylstyrene vapors and unsaturated hydrocarbons was observed at the plant site.

Table 1

Pollution of Atmospheric Air Around the Synthetic Rubber Plant

Distance From Plant, m	α-Methylstyrene in ml/m³		Unsaturated Hydrocarbons, mg/m³	
	Concentration Fluctuations	Most Frequent Values	Concentration Fluctuations	Most Frequent Values
Territory of Synthetic rubber plant	$\frac{0{,}080-3{,}700}{1{,}389^{*}}$	0,400–3,200	$\frac{0{,}000-13{,}600}{7{,}725}$	3,800–11,400
500	$\frac{0{,}068-0{,}800}{0{,}336}$	0,200–0,538	$\frac{0{,}000-4{,}700}{1{,}054}$	1,100–2,800
750	$\frac{0{,}000-0{,}700}{0{,}207}$	0,100–0,400	$\frac{0{,}000-6{,}650}{1{,}681}$	0,025–2,700
1000	$\frac{0{,}000-0{,}130}{0{,}060}$	0,040–0,130	$\frac{0{,}000-5{,}560}{0{,}459}$	0,095–2,300
1500	$\frac{0{,}000-0{,}260}{0{,}060}$	0,026–0,120	$\frac{0{,}000-11{,}700}{2{,}019}$	1,500–9,860
2000	$\frac{0{,}000-0{,}160}{0{,}024}$	0,016–0,100	$\frac{0{,}000-9{,}860}{1{,}160}$	0,095–7,900
3000	$\frac{0{,}000-0{,}106}{0{,}031}$	0,030–0,080	$\frac{0{,}000-3{,}800}{0{,}561}$	0,095–2,800
4000	$\frac{0{,}000-0{,}010}{0{,}004}$	0,020–0,026	0	0
5000	0	0	0	0

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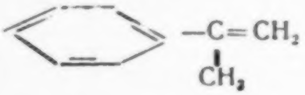
* The denominator is the average of highest single values.

Unsaturated hydrocarbons pollute atmospheric air in the zone up to 3000 meters, and α-methylstyrene vapors, up to 4000 meters. At a distance of 5000 m from the plant site, no atmospheric pollution with gaseous discharges was observed.*

Thus, the studies showed that one of the principal toxic agents which is most extensively dispersed around the synthetic rubber plant is α-methylstyrene.

α-Methylstyrene (isopropylbenzene; 1-methyl, 1-phenylethylene; 2-phenylpropylene; β-phenylpropylene) is a homolog of benzene with one unsaturated bond in the side chain. It belongs to a class of isocyclic compounds with a closed ring chain of carbon atoms; its chemical formula is C_9H_{10}, and its molecular weight, 118.18;



Structural Formula of α-methylstyrene

The specific gravity is 0.914, the boiling point 162-163°C., and the freezing point, -31°C.; it is an almost colorless, slightly yellowish liquid with a characteristic odor of naphthalene, practically insoluble in water.

The vapor of α-methylstyrene mixed with air forms explosive mixtures. The upper explosive limit is 6.1% by volume, and the lower limit, 1.1% by volume.

α-Methylstyrene is used in the production of synthetic rubber, styrylated alkyd resins and styrylated drying oils, and is obtained by dehydrogenation (catalytic and thermal) of isopropylbenzene.

α-Methylstyrene belongs to a group of compounds possessing narcotic and irritant properties in high concentrations.

The principal route by which α-methylstyrene enters the human organism is inhalation.

The toxic effect of α-methylstyrene has been studied by a number of Soviet and foreign authors in both acute and chronic experiments.

In the present paper, we shall indicate only the results of studies of those authors who investigated the effect of α-methylstyrene during a short-term action on the organism of man and animals.

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* α-Methylstyrene was determined by the method of M. V. Alekseyeva and N. A. Krylova (1962), and unsaturated hydrocarbons by the method of V. A. Morozov (1955).

Thus, according to G. A. Ogleznev's data (1964) treated by Burns' method, the average effective dose for gastric administration (DL_{50}) was 5.0 ± 0.2 g/kg for mice and 10.25 ± 0.6 g/kg for rats.

In acute poisoning, there is a predominance of symptoms of a pronounced, progressive depression of the central nervous system. The mice died on the first day, and the rats on the second or third day.

According to the data of N. V. Lazarev (1963), a concentration of α-methylstyrene vapor of 10-15 mg/l after a two-hour inhalational exposure caused only sluggishness in white mice, but, as was indicated by Wolf et al. (M. A. Wolf, 1956), these same concentrations of α-methylstyrene vapor after a 7-8 hour inhalation per day caused the death of all the animals on the fourth day of exposure.

The threshold of the reflex effect of α-methylstyrene vapor on the central nervous system of rabbits causing a change in the duration of the flexing reflex and in the rate of development of the reflex muscular tension after a 40-minute exposure is 0.06-1.0 mg/l, according to the data of M. L. Rylova (1955). The threshold of the reflex action of α-methylstyrene vapor on the central nervous system of the cat, determined by the conditioned reflex method after a 30-minute exposure, is equal to 0.04 mg/l (A. I. Korbakova, 1961).

According to M. L. Rylova's determination (1955), the threshold of odor perception of α-methylstyrene vapor and the threshold of its irritant action on people is 0.02 mg/l. It should be noted, however, that M. L. Rylova in her investigations obtained α-methylstyrene concentrations by calculation, and the subjects inhaled the gaseous mixture from the chamber by means of a gas mask.

Cases of acute poisoning with α-methylstyrene vapor in industry have not been reported in the literature available to us.

In our studies of the influence of low concentrations of α-methylstyrene vapors on the human organism, we used the dynamic method of supply of the substance studied, as described by V. A. Ryazanov, K. A. Bushtuyeva, and Yu. V. Novikov (1957).

The selected concentrations of α-methylstyrene vapor were determined by a spectrophotometric method developed by M. V. Alekseyeva, N. A. Krylova, and V. A. Khrustaleva (1963).

The threshold of odor perception of α-methylstyrene vapor was determined on 19 subjects aged 17 to 38 years. Eight different concentrations of α-methylstyrene vapor were tested, and 493 observations were made.

The threshold of odor perception of α-methylstyrene vapor in the persons studied ranged from 0.1 to 0.6 mg/m^3. For the most sensitive persons, the perception threshold was 0.1 mg/m^3.

A concentration of 0.08 mg/m^3 was found to be the subthreshold value (Table 2).

Table 2

Threshold of Odor Perception of α-Methylstyrene Vapors in the Subjects

Number of Subjects	Concentration of α-Methylstyrene Vapor in mg/m^3	
	Minimum Perceptible Concentrations	Maximum Imperceptible Concentrations
3	0,1	0,08
5	0,2	0,10
7	0,4	0,20
4	0,6	0,40

In the determination of the odor perception threshold of α-methylstyrene vapor, it was found that in concentrations close to the threshold value, the vapor has a pleasant aroma resemgling that of the bird cherry.

A study of the influence of low concentrations of α-methylstyrene vapor on the reflex reactions of the organism was made by the method of dark adaptation of the eye on three subjects having the lowest (0.1 mg/m^3) odor perception threshold of this substance.

Our studies showed that the threshold and above-threshold odor perception concentrations of α-methylstyrene vapor cause reflex reactions in the respiratory organs while at the same time changing the light sensitivity of the eye.

These changes in subjects P. G. and M. A. were expressed in a decrease of the light sensitivity of the eye in the 20th minute. In subject G. N. during the same time interval, an increase in light sensitivity was observed which was replaced by an abrupt decrease in the 25th minute.

Statistical treatment of the results showed these changes in light sensitivity to be significant.

α-Methylstyrene vapor in the subthreshold odor perception concentration (0.08 mg/m^3) caused no changes in the light sensitivity of the eye.

Our results as well as those of other authors show that there are a number of substances which in subthreshold odor perception concentrations have no effect on the functional state of the visual analyzer as determined by the dark adaptation method (K. A. Bushtuyeva, 1957, 1961; M. T. Takhirov, 1960; N. F. Izmerov, 1961; A. V. Mnatsakayan, 1961; V. P. Melekhina, 1962).

As was shown by K. A. Bushtuyeva, Ye. F. Polezhayeva, and A. D. Semenenko (1960), the method of electroencephalographic study of the effect of low concentrations of atmospheric pollutants on the human organism permits a direct determination of the effect of chemical stimuli on the cerebral cortex.

Subsequent studies by V. A. Gofmekler (1960), G. I. Solomin (1961), B. Mukhitov (1963), and other authors confirmed the conclusions reached by Bushtuyeva et al. concerning the high sensitivity of electroencephalographic tests in the study of the effect of atmospheric pollutants on man.

Therefore, the next stage of our work was to investigate the effect of low concentrations of α-methylstyrene vapor on the bioelectric activity of the human cerebral cortex with the aid of quantitative analysis of the total bioelectric activity of the cerebral cortex developed by A. D. Semenenko (1964). The tests were conducted on four subjects whose threshold of odor perception of α-methylstyrene vapors was $0.1\ mg/m^3$.*

Our analysis of the electroencephalograms involved the use of the total bioelectric activity of the human cerebral cortex in the course of rhythmic photic stimulation.

The subjects developed conditioned motor reflexes to a photic stimulus supplied in the form of intermittent light with a flicker frequency close to the frequency of the subjects' α-rhythm.

The tests were conducted in the same time periods. A session lasting 21 minutes consisted of 18 cycles.

Each cycle included: a sound stimulus (7-8 sec), a waiting period (8-9 sec), a light stimulus 35 sec), and muscular limbering up (20 sec).

Thus, all our observations were made with the same background. The higher nervous activity during the experiment was occupied each time with the same reaction, with a maximum elimination of possible manifestation of extraneous psychic processes not related to the experimental conditions.

During the study, the subject sat in a comfortable chair in an insulated, soundproof, dimly lit room.

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* The study was made at the Institute of General and Communal Hygiene of the Academy of Medical Sciences of the USSR im. A. N. Sysin under the direction of A. D. Semenenko.

Pure air or a gaseous mixture (depending on the experimental conditions) was supplied to a smelling cylinder placed before the subject's face at a rate of 35 l/min.

The biopotentials of the cerebral cortex were taken off by the bipolar method from four regions: right temporal and occipital (T_dO_d), left temporal and occipital (T_sO_s), left temporal and right frontal (T_sF_d); and right temporal and left frontal (T_dF_s), and were recorded with a 16-channel "Galileo" electroencephalograph.

The quantitative analysis of the average biocurrent voltage of the cerebral cortex was carried out with a multichannel integrator designed by B. N. Balashov (1964).

After the training periods, during which the subjects became accustomed to the conditions of the experiment and began to give relatively stable readings of the electric activity of the cerebral cortex, we began our investigations.

In the course of 24 hours, only one session of observations with pure air or a given concentration of α-methylstyrene vapor was conducted.

On the day of the study, when the effect of α-methylstyrene on the bioelectric activity of the cerebral cortex was investigated, the first three cycles corresponded to pure air, and in the fourth cycle, before the presentation of the photic stimulus, the gaseous mixture was supplied to the smelling cylinder until the end of the sound stimulus of the next (fifth) cycle. Then, after air was supplied in the sixth cycle, the gaseous mixture was admitted again, and so on until the 15th cycle inclusive. In the last three cycles, only pure air was supplied to the smelling cylinder.

We took a total of 80 electroencephalograms and studied the influence on the bioelectric activity of the cerebral cortex of three α-methylstyrene concentrations: 0.10, 0.06, and 0.04 mg/m^3.

It was found that α-methylstyrene vapor in concentrations of 0.10 and 0.06 mg/m^3 affects the bioelectric activity of the cerebral cortex.

In subjects Ye. M. and I. A., α-methylstyrene vapor in concentrations of 0.10 and 0.06 mg/m^3 caused a decrease in the energy of the α-rhythm, whereas an increase was observed in subjects N. G. and G. N.

Statistical treatment of the data obtained showed that changes in the electric activity of the cerebral cortex caused by the action of α-methylstyrene vapor in the indicated concentrations are significant.

A concentration of α-methylstyrene vapor of 0.04 mg/m^3 was found to be inactive for all the subjects.

Thus, our outdoor and experimental studies lead to the following conclusions:

1. The threshold of olfactory perception of α-methylstyrene vapor and of its reflex effect on the light sensitivity of the eye for the most sensitive persons is 0.1 mg/m^3.

2. The threshold of the reflex effect of α-methylstyrene vapor on the bioelectric activity of the human cerebral cortex is 0.06 mg/m^3, and a concentration of 0.04 mg/m^3 was found to be inactive in this method of investigation.

3. The concentration of 0.04 mg/m^3, which did not cause any subjective sensations or reflex reactions in the human organism, can be recommended as the highest single maximum permissible concentration of α-methylstyrene vapor for atmospheric air in populated areas.

4. The investigated synthetic rubber plant is a source of atmospheric pollution with α-methylstyrene vapor in the zone up to 3000 m, where the highest single concentrations reach 0.106 mg/m^3; this substantially exceeds the maximum inactive concentration which we established.

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SANITARY EVALUATION OF VALERIC ACID AS AN ATMOSPHERIC POLLUTANT

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From Ministerstvo Zdravoochraneniya RSFSR. Moskovskiy Nauchno-Issledovatel'skiy Institut Gigieny Im. F. F. Erismana. "Voprosy gigieny atmosfernogo vozdukha i planirovki naselennykh mest". Uchenye zapiski, Moskva, p. 10-15, (1968).

The development of production of synthetic fatty acids and their extensive use in various branches of the national economy calls for a sanitary evaluation of these indices as sources of atmospheric pollution. The chief source of atmospheric pollution in the production of fatty acids are the oxidizing towers. Tentative analyses of the air escaping from the oxidizing towers have shown that fatty acids predominate in these discharges. In addition to fatty acids, the composition of industrial discharges includes hydrocarbons, ketones, synthetic alcohols, aldehydes, etc. Studies conducted by the F. F. Erisman Institute on the atmospheric air around plants producing fat substitutes show a steady pollution of this air with synthetic fatty acids. The content of synthetic fatty acids in atmospheric air at various distances from a fat-substituent plant is shown in Table 1.

Table 1

Fatty Acid Content in Atmospheric Air Around Fat-Substituent Plants (in mg/m^3)

Distance From Source, km	Maximum Concentrations		
	Shebekino Chemical Complex	Volgodonsk Chemical Complex	Berdyansk Plant
0,5	0,48	0,9	0,9
1,0	0,50	1,5	1,3
3,0	0,76	0,2	0,33
5,0	0,00	0,3	0,66

Among the synthetic fatty acids present in industrial discharges, those of greatest interest are the most volatile fatty acids (C_1-C_9). The end products of this industry are fatty acids, from valeric to arachidic acid.

After analyzing this group of acids, we found that the most volatile is valeric acid, which we chose as the object of our study.

Valeric acid ($C_5H_{10}O_2$) is an oily liquid with a very unpleasant odor. Its boiling point is 187°C., melting point -34.5°C., and specific gravity 0.939 at 20°C. (Chemist's Handbook, 1964).

The purpose of our studies was to substantiate the maximum permissible concentrations of valeric acid in atmospheric air. To this end, we determined its threshold of olfactory perception and studied the influence of low concentrations of the substance on the reflex change of the light sensitivity of the eye and electrical activity of the brain in man.

The threshold of olfactory perception of valeric acid was studied by using a procedure recommended by the Committee on Sanitary Protection of Atmospheric Air (V. A. Ryazanov et al., 1957). The observations were made on 18 persons aged 17 to 46 years. According to our earlier studies, the threshold of olfactory perception of valeric acid* was 0.5 mg/m^3.

Table 2

Threshold of Olfactory Perception of Valeric Acid in mg/m^3

Number of Subjects	Concentration	
	Minimum Perceptible	Maximum Imperceptible
5	1,3	1,0
4	0,1	0,7
1	0,8	0,7
2	0,7	0,5
2	0,5	0,1
2	0,1	0,09
2	0,09	0,07

We have now refined this threshold of olfactory perception. The studies showed that the minimum perceptible concentration of valeric acid ranged from 1.3 to 0.09 mg/m^3, this range being 0.1-0.09 mg/m^3 in the most sensitive persons of this group. The odor of valeric acid in a concentration of 0.07 mg/m^3 was imperceptible.

Studies of the light sensitivity of the eye were carried out on an ADM adaptometer on four subjects with a normal visual acuity.

Results of the study showed that valeric acid in concentrations from 0.5 to 20 mg/m^3 causes significant changes in the light sensitivity of the eyes. The action of concentrations from 1.4 to 20 mg/m^3 caused changes in the light sensitivity of the eyes in all the subjects. Valeric acid concentrations of 0.5-1.2 mg/m^3 caused significant changes in only two subjects. Concentrations from 0.1 to 0.49 mg/m^3 did not cause any changes in the light sensitivity of the eyes in any of the subjects.

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* Journal Gigiyena i sanitariya (Hygiene and Sanitation), 1961, 12.

Thus, the threshold of action of valeric acid on the functional state of the visual analyzer determined by the dark adaptation method is equal to 0.5 mg/m^3.

In the last few years, the electroencephalographic method using functional loads has been adopted as a sensitive indicator of the functional state of the central nervous system in sanitary studies. Studies by Yu. M. Fel'dman, 1960; Li Shêng, 1961; D. G. Odoshashvili, 1962; K. A. Bushtuyeva, 1963, and others showed that in many cases the electroencephalographic method reveals the effect on man of lower concentrations of toxic substances polluting atmospheric air as compared with those affecting the light sensitivity of the dark-adapted eye.

The study was made by using the method of A. D. Semenenko (1963), based on an evaluation of the functional state of the human cerebral cortex with the aid of varying intensities of light flashing at the frequency of the intrinsic potentials of the subject's brain. The action of additional afferentation taking place when the substance studied is added to air leads to a change in the functional state of the central nervous system and hence to a change in the response to light. The author evaluated the shifts taking place from the change in the total electric activity of the cerebral cortex, whose numerical characteristic was obtained with an integrator built by the engineer B. N. Balashov.

Studies were made on three subjects having the lowest threshold of odor perception of valeric acid. For two persons (T. P. and V. D.) it was 0.09 mg/m^3, and for one (G. Ye.), 0.1 mg/m^3. The subjects ranged in age from 17 to 28 years.

The electroencephalogram was recorded with a four-channel electroencephalograph of the VNIIMIO (All-Union Scientific Research Institute of Medical Instruments and Equipment). Automatic analysis of the total bioelectric activity was carried out with a four-channel integrator of B. N. Balashov's system, built by the electrotechnical laboratory of the Erisman Institute.

During the study, the subjects sat in chairs in a soundproof, insulated, dimly lit room. Air was fed at a rate of 30 l per minute into a glass cylinder located in front of the person. The gas mixture under study was supplied at the same rate. The source of light stimulation was located at a distance of about 1 meter from the subject's eyes. The intensity of the flashes was 5×10^{-2}, 10×10^{-2}, and 15×10^{-2} J. The frequency of the flashes was 10 Hz. The electroencephalogram was taken in bipolar fashion off the temporal regions of both hemispheres.

Each study consisted of 12 cycles composed of a given sequence of stimuli. The cycle started with a sound signal produced by a ZG-10 sound generator and lasting 7-8 sec. During the action of the sound, its loudness was changed 2-3 times. This was followed by a pause (7-8 sec), during which the subject assumed a comfortable position, and by light stimulation for 20 sec. The intensity of the flashes was changed on the 10th and 15th seconds. In the course of the study, the subject responded to every change of the light and sound signal by pressing a sensing element with his hand.

The treatment of the data included the total electric activity of the cerebral cortex during the 6-20 sec of action of light. Relative values of the bioelectric activity are given below. The average activity for 1-3 min (1-3 cycles) of the study was taken as 100%. In studies where the effect of valeric acid was investigated, the necessary gas mixture was supplied intermittently from the fourth through the ninth minute of the study. The supply of the mixture of valeric acid vapor and air was started immediately before the sound stimulation and was discontinued when the light was turned off.

In order to elucidate the effect of valeric acid vapor, the total electric activity of the cerebral cortex was compared during the action of light against a background of breathing of pure air and of the mixture for the same minutes of the experiment.

Three concentrations of valeric acid vapor were used during the study. A valeric acid concentration of 0.12 mg/m^3 caused an increase in the bioelectric activity in the two subjects T. P. and V. D., and an increase followed by a decline in subject G. Ye.

The concentration of valeric vapor was then decreased to 0.07 mg/m^3. It was found to be inactive in subject T. P., and in subject G. Ye. there was only a reinforcement of the electric activity of the cerebral cortex. The nature of the shifts in subject V. D. remained unclear.

An even lower concentration, equal to 0.034 mg/m^3, of valeric acid vapor did not cause any changes in the bioelectric activity of the cerebral cortex in any of the subjects.

The figure shows the results of studies made on subject G. Ye. Periods of the experiment in minutes are plotted along the magnitude of the response along the ordinate. The investigated mixture was supplied intermittently from the 4th to the 9th minute of the study. Statistical treatment of the data obtained was carried out by two methods: the range method, and the method of comparison of natural pairs of variants (A. I. Venchikov, 1963). The latter method allows for the presence of bidirectional shifts in the EEG under the influence of the stimulus. It is therefore more suitable for this type of studies.

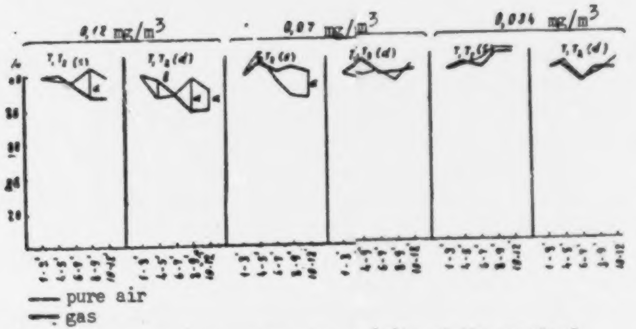

Fig. 1. Change in the electric activity of the cerebral cortex in subject G. Ye. under the influence of valeric acid vapor.

The statistical treatment showed a concentration of 0.07 mg/m^3 of valeric acid to be inactive for subject T. P. and a concentration of 0.034 mg/m^3 to be inactive for subjects G. Ye. and V. D.

Comparing the content of synthetic fatty acids detected in atmospheric air (Table 1) with the inactive concentration of valeric acid (0.034 mg/m^3), we note that the latter concentration has been exceeded 6 to 44-fold.

The studies lead to the following conclusions:

1. Valeric acid, a representative of volatile fatty acids, is a source of atmospheric polluants present in discharges from the production of fat substituents.

2. During the inhalation of air whose composition includes small centrations of valeric acid, the following biological effects are detected in the subjects:

a) The threshold of olfactory perception of valeric acid vapor for the most sensitive persons is 0.09 mg/m^3;

b) A study of the reflex effect of valeric acid vapor established that the light sensitivity of the eye changes at a concentration of 0.5 mg/m^3, concentrations from 0.49 mg/m^3 to 0.1 mg/m^3 causing no significant changes; changes in the electrical activity of the cerebral cortex were recorded during inhalation of a concentration of 0.07 mg/m^3. A concentration of 0.034 mg/m^3 was found to be inactive.

3. On the basis of the above, the highest single maximum permissible concentration of valeric acid for atmospheric air which can be proposed is 0.03 mg/m^3.

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DATA FOR VALIDATING THE MAXIMUM PERMISSIBLE CONCENTRATION OF BUTYRIC ACID IN ATMOSPHERIC AIR

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From Ministerstvo Zdravoochraneniya RSFSR. Moskovskiy Nauchno-Issledovatel'skiy Institut Gigieny Im. F. F. Erismana. "Voprosy gigieny atmosfernogo vozdukha i planirovki naselennykh mest". Uchenye zapiski, Moskva, p. 27-33, (1968).

The substitution of products obtained from petroleum, coal, and gas for plant and animal raw materials is currently assuming an increasing importance in the national economy. One of the major chemical industries is the production of fat substituents.

The synthesis of fatty acids consists in a controlled catalytic oxidation of hydrocarbons with atmospheric oxygen. The acids are prepared from petroleum paraffins as the starting materials, potassium permanganate being used as the catalyst.

In the course of the technological process, a large number of organic products are formed which may escape into the air of the plant buildings and thence into the atmosphere.

Among the organic substances polluting the air in the production of fatty acids, the most significant ones are the fatty acids themselves, whose concentration amounts to an average of 2607 mg/m^3 in the waste gases after combustion (F. I. Dubrovskaya).

The observed maximum concentrations of fatty acids in the vicinity of plant complexes producing synthetic fatty acids amounted to 1.24 mg/m^3 at a distance of 3000 m.

A criterion for the evaluation of the degree of atmospheric pollution by various ingredients are their maximum permissible concentrations.

Hence, in order to give a sanitary evaluation of the degree of pollution of atmospheric air by fatty acids, it is necessary to have the maximum permissible concentration of total fatty acids.

However, before studying the combined action of fatty acids, it is necessary to examine the influence of the individual acids on the physiological functions of the organism and their toxicodynamic characteristics.

The object of the present study was to investigate the influence of one of the fatty acids - butyric acid - on the physiological functions of the organism and its toxicodynamic aspects in a chronic experiment.

Butyric acid is a colorless liquid with a specific gravity of 0.9577 and a pungent, unpleasant odor resembling that of some types of cheese. Butyric acid is a saturated fatty acid (with an unbranched chain).

Butyric acid is present as hexyl ester in the fruits of cow parsnip, as octyl ester in parsnip, and as the glyceride (in amounts up to 2%) in animal oil.

In the free form, butyric acid is found in rancid oil, muscle juice, perspiration, and animal excrements.

Butyric acid is used in the rubber industry, in the decaleination of leather in tanning, and in chromatography. Esters of butyric acid find applications in perfume manufacture, as the starting materials in the production of cellulose acetobutyrate, and is used as the starting material in the production of a new type of plastic - etrol.

The method of determination of monobasic carboxylic acids of the fatty series is based on the conversion of the fatty acids into methyl esters and determination of the esters formed with hydroxylamine and ferric chloride. The color of the solution developed as a result of this reaction is matched with a scale. The sensitivity of the method is 0.005 mg in the volume analyzed. The method is nonspecific. Complex esters and anhydrides of organic acids interfere with the determination (Yu. V. Dyuzheva).

Rabbits that inhaled butyric acid in a concentration of 400 mg/m^3 for 1.4 hours showed labored breathing and an increasing sluggishness. X-ray and histological examinations revealed congestion, edema, atelectasis and emphysema of the lungs (S. L. Danishevskiy).

A repeat inhalation of vapors in the amount of 200-300 mg/m^3 by white rats for 2 hours daily in the course of three month produced a slight effect (K. P. Stasenkova, T. A. Kochetkova).

In the literature that we searched, no data are given on the influence of lower butyric acid concentrations on the organism.

In order to study the reflex effect of butyric acid, we investigated the odor threshold, the change in the light sensitivity of the eye, and the influence of low concentrations on the electric activity of the cerebral cortex.

The determination of the odor threshold of butyric acid involved the participation of 17 persons aged 17-35 years. All the subjects were essentially healthy without any pathologic changes of the nasal cavity and with a normal olfactory acuity. The odor of butyric acid was determined in comparison with the inhalation of pure air.

The studies were made with seven concentrations, from 1.0 mg/m^3 to 0.04 mg/m^3 butyric acid, and showed that for the most sensitive persons, the minimum perceptible concentration was 0.06 mg/m^3, while the 0.04 mg/m^3 concentration was the maximum imperceptible value.

The reflex effect of low butyric acid concentrations on the functional state of the central nervous system was studied by determining the light sensitivity of the eye under dark adaptation conditions.

The studies were carried out in accordance with a standard procedure. The observations were made on essentially healthy persons with a normal vision and sense of smell.

The studies of the light sensitivity of the eyes were conducted on four subjects with three butyric acid concentrations: 0.08, 0.06 and 0.04 mg/m^3.

They showed that for two subjects, the minimum active concentration was 0.06 mg/m^3, which coincided with the odor threshold concentration. The 0.04 mg/m^3 concentration was found to be inactive for all four subjects.

At the present time, it is certain that a conditioned reflex connection can be formed in man between two indifferent stimuli. The bioelectric reactions of the cerebral cortex, in particular, to a photic stimulus, are used by many investigators as unconditioned reflex reactions. The possibility of developing a conditioned reflex depression of the alpha rhythm to odors, using continuous light as the unconditioned stimulus, was utilized by K. A. Bushtuyeva and A. D. Semenenko (1960) for standardizing atmospheric pollutants. However, the lack of a quantitative criterion makes this procedure largely subjective in dealing with near-threshold intensities of the conditioned stimulus, when it is difficult to differentiate a conditioned reflex depression of the alpha rhythm from a spontaneous depression.

In view of the high sensitivity of the conditioned reflex method, we considered it desirable to conduct further research for the purpose of developing a new conditioned reflex method satisfying the requirements of sanitary standardization, i. e., to determine the feasibility of a quantitative characterization of the phenomenon in question. To this end, attempts were made to develop a conditioned reflex to the odor of butyric acid in low concentrations, using rhythmic light as the unconditioned stimulus.

An attempt was made to detect the influence of the conditioned stimulus on the unconditioned stimulus. The presence of an analyzer and an integrator enabled us to judge the shifts observed not only from the total bioelectric activity but also directly from the reaction to the rhythmic stimulus.

The conditioned stimulus was butyric acid in concentrations of 0.06, 0.03, and 0.015 mg/m^3.

The unconditioned stimulus was rhythmic light. Each subject was exposed to a photic stimulation frequency that he readily assimilated: this frequency was 8 Hz for subject I. V., and 10 Hz for the remaining subjects V. M., V. Ye. and M. Kh.

In course of a single study, 10 pairings of the conditioned stimulus with the unconditioned stimulus were made.

Since we were interested in the influence of the conditioned on the unconditioned stimulus, the development of the conditioned reflex was preceded by a series of studies to determine the magnitude of the unconditioned reaction and of the reaction to the rhythmic photic stimulus. Only after this was established did we start the development of the conditioned reflex. This development was begun with the maximum concentration of butyric acid, 0.06 mg/m^3, equal to its odor perception threshold. Bearing in mind that the conditioned reflexes to weak stimuli are very unstable and that in man the development of such conditioned reflexes takes place rapidly (K. A. Bushtuyeva et al.), each concentration, i. e., each intensity of the conditioned stimulus, was used for 5 days (50 pairings). In order to detect the formation of the conditioned to the unconditioned stimulus, a statistical treatment was carried out using the method of comparison of natural pairs of variants.

Combining the weak odor stimulus with the rhythmic photic stimulus we were able to: 1) develop the conditioned reflex to the odor of butyric acid in concentrations of 0.06 mg/m^3 and 0.03 mg/m^3 and 2) detect the influence of these intensities of the conditioned stimulus on the course of the unconditioned reflex reaction. These shifts were statistically significant in character. The presence of conditioned reflex reactions and of the influence of the conditioned stimulus on the course of the unconditioned reaction was also noted in the presence of a very weak conditioned stimulus - the odor of butyric acid in a concentration of 0.015 mg/m^3. However, these reactions were unstable in character and were found not to be statistically significant after the statistical treatment of the data.

In order to validate the mean daily maximum permissible concentration of butyric acid in atmospheric air, we performed a chronic round-the-clock (94-day) exposure of white rats (males) to this acid.

The object of this part of the study was to detect the changes occurring in the organism of the experimental animals during a prolonged exposure to butyric acid as a function of the concentration by means of biochemical, physiological and pathomorphological methods of investigation.

Studies were conducted on four groups of rats with 15 rats in each group. A mixture of air and acid was supplied to 100-liter exposure chambers at a rate of 30-35 liters per minute.

The butyric acid content in chamber 1 during the exposure ranged from 0.09 to 0.8 mg/m^3 and amounted to an average of 0.144 mg/m^3; in chamber 2, from 0.012 to 0.032 mg/m^3, average 0.018 mg/m^3, and in chamber 3, from 0.003 to 0.016 mg/m^3, average 0.0076 mg/m^3. Animals in chamber 4 served as the control.

During the exposure, observations were made on the general condition of the animals, their weight, changes in the alkaline reserve of whole blood, change in the chlorides of the blood, content of erythrocytes and hemoglobin, and amount of oxygen consumed (after Miropol'skiy), and the latent reflex time was determined.

Butyric acid had no appreciable effect on the general condition and weight of the animals. Toward the end of the exposure, all the rats gained weight.

The alkaline reserve of whole blood was determined by the method of Derviz.

As we know from literature data, in healthy animals the alkaline reserve of the blood is 110-115 meq/1. We obtained such figures by studying the animals before the start of the experiment.

After the experimental animals had been in the chambers for two weeks, we observed a sharp decrease in the alkaline reserve of the blood in the groups of rats in chambers 1 and 2, where the concentrations corresponded to 0.15 mg/m^3 and 0.015 mg/m^3 (Fig. 1).

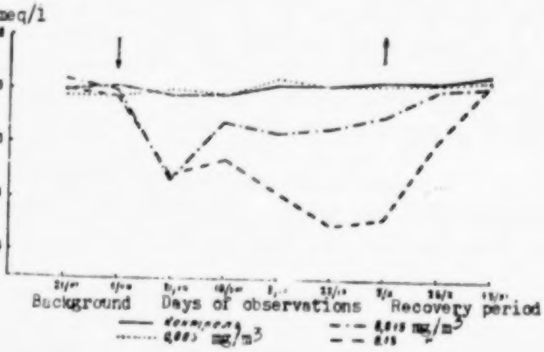

Fig. 1. Change in the alkaline reserve of whole blood of rats during inhalation of butyric acid.

Statistical treatment of the data showed that the changes in the alkaline reserve of the blood were significant. The greatest changes were found in rats of the first chamber. In rats of the control group and those in chamber 3 (0.0076 mg/m^3), the fluctuations of the alkaline reserve of the blood were within the normal range. Forty days after the end of the exposure, the alkaline reserve of the blood was restored in all the animals.

The chlorides in the blood were determined by Levinson's method (Fig. 2).

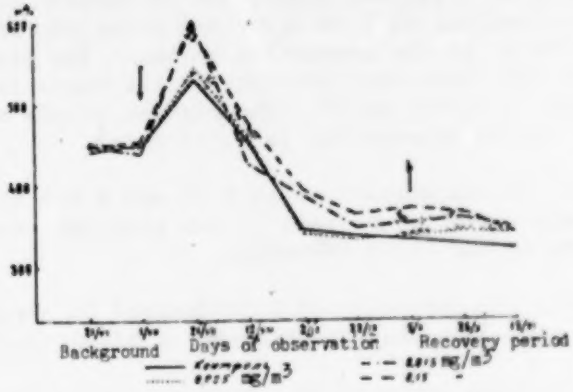

Fig. 2. Dynamics of change in the chlorides of the blood of rats during inhalation of butyric acid.

After the experimental animals were placed in the chambers, an increase in the blood chlorides was observed, with the sharpest increase in the course of the entire experiment taking place in rats in chambers 1 and 2.

Statistical treatment of the data, carried out on the 60th day from the start of the experiment, showed that the changes are significant in the group of rats in chambers 1 and 2 as compared with the control group.

No changes in the content of chlorides in the blood of rats present in chamber 3 were observed as compared with the control group.

Relative to the control group, no changes were observed in the content of blood chlorides in rats of chamber 3.

Toward the end of the recovery period, a narrowing of the gap between the content of chlorides of groups I and II and the control group was observed.

The content of erythrocytes and hemoglobin in all the groups of experimental animals was in the range of physiological norms. We should mention, however, a decreasing trend in the number of erythrocytes in the blood of rats of the first group.

As far as the determination of the amount of consumed oxygen and latent reflex time is concerned, we did not obtain a statistically significant boundary between the experimental and control groups of animals by using these indicators.

Conclusions

1. The threshold of olfactory perception of butyric acid for the most sensitive persons corresponds to 0.06 mg/m^3 and coincides with the threshold concentration established by the adaptation method. The threshold of action of this substance on the electrical activity of the brain is 0.03 mg/m^3; the inactive concentration is 0.015 mg/m^3. The highest single maximum permissible concentration which can be recommended is 0.015 mg/m^3.

2. Butyric acid in concentrations of 0.15 and 0.015 mg/m^3 in chronic exposure of white rats causes a decrease in the alkaline reserve of whole blood and an increase in the blood chlorides.

Butyric acid in a concentration of 0.0076 mg/m^3 in chronic action on white rats does not cause the changes observed at higher concentrations.

The mean daily maximum permissible concentration of butyric acid which can be recommended is 0.005 mg/m^3.

INTERACTION OF CONDITIONED AND UNCONDITIONED STIMULI IN THE PRESENCE OF A COMBINATION OF LOW CONCENTRATIONS OF BUTYRIC ACID AND RHYTHMIC LIGHT IN MAN

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From Ministerstvo Zdravoochraneniya RSFSR. Moskovskiy Nauchno-Issledovatel'skiy Institut Gigieny Im. F. F. Erismana. "Voprosy gigieny atmosfernogo vozdukha i planirovki naselennykh mest". Uchenye zapiski, Moskva, p. 34-41, (1968).

I. P. Pavlov's teaching on the higher nervous activity enabled the physiologist for the first time to make objective studies of the functions of the cerebral cortex, a higher branch of the central nervous system which is not only responsible for a closer adaptation of the organism to the steadily changing environment, but is also the most sensitive to adverse changes in this environment.

Even in the very first studies of conditioned connections it was shown that in the development of a conditioned reflex, the reactions caused by the two paired stimuli change. The first stimulus not only acquires the ability to cause the reaction characteristic of the second stimulus, but also alters the reaction associated with its partner. A conditioned reflex can not only inhibit (I. Ya. Perel'tsveyg, 1907; V. F. Shmidt, 1929; A. V. Vorob'yev and A. A. Lindberg, 1932; V. V. Petrovskiy and Yu. P. Fedotov, 1934; A. M. Pavlova, 1935; E. A. Asratyan, 1941; V. V. Rikman, F. P. Mayorov, V. I. Fedorov, 1943) or reinforce the unconditioned reflex (P. S. Kupalov and O. P. Yaroslavtseva, 1935; P. S. Kupalov, 1936; Kostenetskaya, 1940; V. K. Fedorov, 1950; B. I. Khodorov, 1954), but also change its course in time (P. S. Kupalov, 1940, 1941; B. I. Stozharov, 1949; O. P. Yaroslavtseva, 1949).

In the last few years, the phenomenon of interaction of the conditioned and unconditioned stimuli has been thoroughly studied in the laboratory of E. A. Asratyan, Corresponding Member of the USSR Academy of Sciences, in the course of an investigation of conditioned reflexes with an inverse connection (E. A. Asratyan, 1965).

We made an attempt to use the above-indicated forms of interaction of paired stimuli for purposes of sanitary standardization. To this end, studies were made on the development of the conditioned reflex to the odor of butyric acid in low concentrations. The unconditioned stimulus used was rhythmic light at frequencies causing an optimally expressed unconditioned reflex rearrangement of rhythms in the EEG of man (R. A. Pavlygina, 1957, 1960). The presence of an analyzer and integrator made it possible to characterize quantitatively the shifts caused by the conditioned and unconditioned stimuli not only on the basis of the total bioelectric activity, but also directly from the reaction to the rhythmic stimulus (G. N. Boldyreva, 1964).

The observations were made on four persons aged 19 to 38 years. During the studies, performed many times, the subjects were sitting with eyes closed in a darkened, soundproof, and insulated room. Standing in front of each subject was a smelling cylinder with a diffuser through which was supplied either pure air or the gas mixture studied, at a rate of 30 l per minute. The subjects were not aware of the moments when pure air was switcehd to the gas or vice versa.

The recording of the potentials and their analysis were performed with a set of instruments manufactured by the Estergom plant (Hungary). The set included an eight-channel encephalograph and eight-channel band analyzer permitting the separation of frequencies corresponding to the rhythms of the encephalogram. The presence of an eight-channel integrator made it possible to characterize quantitatively the average amplitude of both the encephalogram and the separated rhythm. The EEG were taken off by the bipolar method from the temporal, parietal, and occipital regions. A quantitative analysis of the total encephalogram and range of the alpha rhythm was carried out for the period of action of the conditioned and unconditioned stimuli. Both stimuli acted for 10 seconds each, and were separated by a pause of 1-2 seconds. The magnitude of the reaction was calculated in percent relative to the background. The background used was the average amplitude of the encephalogram and alpha rhythm for the 10 seconds immediately preceding the conditioned stimulus.

The conditioned stimulus was butyric acid vapor in concentrations of 0.06, 0.03, and 0.015 mg/m^3; the unconditioned stimulus was rhythmic light at a frequency of 8 Hz for subject I. V. and 10 Hz for subjects V. M., V. Ye. and M. Kh.

The light source was located at a distance of 1.0 m from the subject's eyes. The light intensity, equal to 13.5×10^{-2} J, was clearly perceived by the subjects through closed eyelids.

In the course of a single study, 10 pairings of the conditioned with the unconditioned stimulus were made.

The development of the conditioned reflex was preceded by a series of studies in which the magnitude of the unconditioned reaction to both the rhythmic photic stimulus and the background activity at the location of the conditioned stimulus were investigated.

The development of the conditioned reflex was started with a maximum concentration of butyric acid vapor of 0.06 mg/m^3, equal to the perception threshold of its odor. Keeping in mind that the conditioned reflexes to weak stimuli are very unstable and that in man the development of such conditioned reflexes is rapid (K. A. Bushtuyeva, 1963), each concentration, i.e., each intensity of the conditioned stimulus, was used for 5 days (50 pairings). To detect the formation of the conditioned reflex and the influence of the conditioned on the unconditioned stimulus, a statistical treatment was carried out by using a method of comparison of natural pairs of variants (A. I. Venchikov, 1963). The following were compared: 1 - electric activity of cerebral hemispheres during the action of the gas as compared to the electric activity immediately preceding the photic stimulation in the "background" series of experiments, when no gas was used, and 2 - reaction to light before and after the development of the conditioned reflex to the odor of butyric acid.

Since the study was made for the purpose of a sanitary standardization, we shall not dwell on the examination of the course of development of the conditioned reflex and its characteristics. However, we think it necessary to give some examples of the forms of bioelectric activity which we observed before and after the development of the conditioned reflex. In subject I. V., the first presentation of light before the development of the conditioned reflex caused a reinforcement of the background activity followed by a reaction of assimilation of the rhythm of the photic flicker. The seventh presentation of light in the same study caused a rhythm assimilation reaction which was most distinct in the occipital takeoff. After the development of the conditioned reflex to the odor of butyric acid in a concentration of 0.015 mg/m^3, in some pairings there was observed a well-defined conditioned reflex reaction of rhythm assimilation in all the recorded regions during the action of the gas, and in other regions, a reinforcement by the conditioned stimulus of the unconditioned reflex reaction of rhythm assimilation in response to the rhythmic photic stimulus, or an unchanging unconditioned reflex reaction in the absence of the conditioned reflex reaction.

Because of the variability of the phenomenon studied and the feasibility of its quantitative characterization with the aid of the integrator readings, we shall henceforth utilize only the results of statistical treatment of the data obtained.

Table 1 listed the results of statistical treatment of the results for the development of the conditioned reflex to the odor of butyric acid in a concentration of 0.06 mg/m^3, where M is the difference of the arithmetic means, m is the difference error, and $t = \frac{M}{m}$.

Attention is drawn to the fact that the values of M turn out to be higher for the alpha rhythm range than for the total EEG. This confirms the data of G. N. Boldyreva (1964) showing that the reaction of rhythm assimilation is best manifested in the separated range of rhythms which include the frequency of the photic stimulation.

Table 1

Obs.	Butyric Acid, 0.06 mg/m^3											
	2–4			6–8			10–12			14–16		
	м	m	t	м	m	t	м		t	м	m	t
V. M.	1,64	2,9	0,56	0,24	2,3	0,1	4,36	3,1	1,4	1,3	3,5	0,34
V. Ye.	0,46	1,8	0,25	1,17	1,07	1,09	6,47	4,01	1,6	1,18	1,41	0,81
I. V.	6,18	1,88	3,28	3,4	3,8	0,9	1,05	3,25	0,3	6,52	4,03	1,6
M. Kh.	0,1	3,9	0,03	2,9	2,84	1,02	1,2			3,9	6,8	0,6

Obs.	Alpha Rhythm			Butyric Acid, 0.06 mg/m^3								
	2–4			6–8			10–12			14–16		
	м	m	t	м	m	t	м	m	t	м	m	t
V. M.	2,68	2,9	0,92	—	—	—	5,9	3,7	1,5	0,32	5,2	0,06
V. Ye.	4,16	2,0	2,08	—	—	—	5,78	1,21	4,6	0,32	3,0	0,1
I. V.	8,78	5,9	1,48	—	—	—	5,42	1,97	2,7	7,72	6,1	1,2
M. Kh.	4,1			—	—	—	3,2			0,9	3,3	0,3

Obs.	EEG			Light After Butyric Acid, 0.06 mg/m^3								
	2–4			6–8			10–12			14–16		
	м	m	t	м	m	t	м	m	t	м	m	t
V. M.	7,38	4,2	1,75	5,92	5,75	1,02	1,38	5,8	0,2	10,2	6,2	2,3
V. Ye.	1,8	2,6	0,69	10,07	4,25	2,1	0,75	3,46	0,21	9,44	8,57	1,1
I. [illegible].	1,98	4,5	0,44	4,5	7,7	0,58	1,8	2,7	0,7	1,6	5,0	0,32
M. Kh.	3,7	3,3	1,1	0,4	2,5	0,16	9,2	0,2	0,9	1,8	1,8	2,0

Obs.	Alpha Rhythm			Light After Butyric Acid, 0.06 mg/m^3								
	2–4			6–8			10–12			14–16		
	м	m	t	м	m	t	м	m	t	м	m	t
V. M.	12,44	3,94	3,1	—	—	—	7,6	6,1	1,2	14,66	9,3	1,5
V. Ye.	3,1	4,7	0,6	—	—	—	4,2	9,4	0,44	6,38	10,53	0,6
I. V.	6,03	9,1	0,66	—	—	—	15,62	17,1	0,9	0,66	8,5	0,07
M. Kh.	6,0	7,6	0,8	—	—	—	13,5	2,9	4,3	9,8	6,1	1,6

The considerable variability of the phenomenon in question, which we pointed out above, is expressed in the large values of m.

Similar data were obtained for the other intensities of conditioned stimulation -- butyric acid vapor in concentrations of 0.03 and 0.015 mg/m^3. The presence of a large amount of numerical data hinders the detection of regular shifts in the course of the use of a conditioned stimulus of varying intensity. In order to detect the regions of the cortex of the cerebral hemispheres where the stimuli employed cause the largest shifts, Table 2 gives the values of t separately for different intensities of the conditioned stimulus.

During the action of the conditioned stimulus, the largest shifts take place at its highest intensity (of those studied): 0.06 mg/m^3 of butyric acid. These shifts are found to be most distinct for the alpha rhythm range in the temporal and sincipital takeoffs, i.e., leads that are reached by impulses from olfactory stimulations. As the conditioned stimulus is weakened to 0.03 mg/m^3 of butyric acid, the shifts become smaller, but continue to remain statistically significant. On the other hand, when the conditioned stimulus -- butyric acid -- is present in a concentration of 0.015 mg/m^3, they become statistically insignificant.

A change in the course of the reaction to the unconditioned stimulus -- rhythmic light -- under the influence of the conditioned stimulus takes place in all the leads.

The intensity of the influence of the conditioned on the unconditioned stimulus also depends on the strength of the conditioned stimulus. This is pronounced, and is statistically significant in character for an intensity of the conditioned stimulus of 0.06 and 0.03 mg/m^3 butyric acid and is considerably weaker and statistically insignificant at a butyric acid concentration of 0.015 mg/m^3.

With only one available quantitative treatment of the data, we cannot discuss the types of manifestation of the conditioned reflex reaction in the form of an influence of the activity waves on the action of the conditioned stimulus in the rhythm of the photic flicker or in the form of a depression of the basic rhythm (G. N. Boldyreva, 1964, and others). However, the cortical regions of the cerebral hemispheres in which we observed the most distinct shifts fully correspond to the data obtained earlier by other investigators (G. N. Boldyreva, 1964, et al.).

In the course of the study we noted a change in the excitability of the conditioned stimulus center, as was shown in special studies on people (A. M. Maruseva and L. A. Chistovich, 1954; G. V. Gershuni, 1957) and animals (N. I. Nikolayeva, 1960; E. A. Asratyan, 1962; U. G. Gasanov, 1965, and others).

Table 2

Obs.	Intensity of Conditioned Stimulus	Conditioned Stimulus								Unconditioned Stimulus							
		EEG				Alpha Rhythm				EEG				Alpha Rhythm			
		2—4	6—8	10—12	14—16	2—4	6—8	10—12	14—16	2—4	6—8	10—12	14—16	2—4	6—8	10—12	14—16
V. M.	0,06 mg/m³	0,56	0,1	1,4	0,34	0,9	—	1,5	0,06	1,75	1,02	0,2	2,3	3,1	—	1,2	1,5
V. Ye.	"	0,25	1,09	1,6	0,81	2,08	—	4,6	1,1	0,69	0,21	0,21	1,1	0,6	—	0,44	0,6
I. V.	"	3,28	0,9	0,3	1,6	1, 8	—	2,7	6,2	0,44	0,7	0,7	0,32	0,66	—	9,9	0,07
M. Kh.	"	0,03	1,02	—	0,6		—		0,3	1,1	0,9	0,9	1,0	0,8	—	4,3	1,6
V. M.	0,03 mg/m³	0,057	0,1	1,39	0,2	0	—	2,6	1,0	0,01	0,3	0,28	0,8	1,3	—	1,1	0,6
V. Ye.	"	0,8	1,1	0,11	0,03	0,6	—	1,3	0,7	0,9	1,1	1,1	0,08	0,3	—	0,9	0,7
I. V.	"	1,4	2,3	0,63	0,57	1,12	—	2,5	1,28	1,0	2,4	0,9	2,6	5,7	—	2,3	2,5
M. Kh.	"	0,2	0,2	1,0	0,43	0,1	—	0,3	1,0	1,4	0,1	0,8	0,9	0,9	—	0,1	0,5
V. M.	0,015 mg/m³	0,4	1,1	0,3	0,23	0,18	—	1,03	0,5	0,6	1,19	0,3	1,7	0,6	—	1,2	1,7
V. Ye.	"	1,41	0,79	0,3	0,54	0,49	—	1,2	0,3	1,9	0,62	0,28	1,21	1,06	—	1,6	0,28

Note to Tables 1, 2:
2—4 — left temporal lead
6—8 — right temporal lead
10—12 — sincipital lead
14—16 — occipital lead

In the course of development of the conditioned reflex to the odor of butyric acid, the excitability of the conditioned stimulus center increased in all the subjects, as reflected in a decrease of the perception threshold of the odor of butyric acid. Whereas before the development of the conditioned reflex the odor perception threshold of butyric acid for the most sensitive subjects was 0.06 mg/m^3, during the development of the conditioned reflex all the subjects perceived the odor of butyric acid in a concentration of 0.03 mg/m^3, and the most sensitive subject, I. V., perceived the odor of butyric acid also in a concentration of 0.015 mg/m^3 in some pairings.

Conclusions

1. The study demonstrates the feasibility of formation of a conditioned reflex connection between a weak olfactory stimulus and rhythmic light, and the influence of the conditioned on the unconditioned stimulus under these experimental conditions.

2. The use of automatic analytical procedures makes it possible to characterize quantitatively the phenomena studied.

3. The higher sensitivity of the method as compared with other methods employed such as the odor threshold and the influence on the light sensitivity of the dark-adapted eye makes it possible to recommend it for sanitary standardization work.

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EFFECT OF LOW CONCENTRATIONS OF EPICHLOROHYDRIN VAPOR ON THE ANIMAL ORGANISM

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Among new chemical substances which lately have become widely accepted in industry, a major one is epichlorohydrin.

First synthesized in 1854 by M. Berthelot and Luca, it became highly popular much later, when P. Castan (1934-1938) showed that it could be used for the preparation of a new group of polymer materials, the so-called epoxy resins. Thanks to a host of valuable properties, epoxy resins are daily assuming an increasing importance in the national economy.

Epichlorohydrin is a colorless, transparent, relatively volatile liquid with a pleasant ester odor. It dissolves well in ether, alcohol, and animal fats, and poorly in water.

There are very few experimental studies dealing with the toxicology of epichlorohydrin. The most comprehensive work along these lines was carried out by S. M. Kremneva and M. S. Tolgskaya (1961).

In acute and chronic experiments on animals (white mice, rats, and rabbits), the authors found that epichlorohydrin has a high toxicity and can have a general resorptive as well as local effect. Depending on the dose and mode of its introduction into the organism, the clinical picture of poisoning may be dominated by disturbances of the functions of certain organs and systems, but in all cases the most pronounced changes are found in the lungs and kidneys.

It should be noted, however, that in studying the chronic effect of epichlorohydrin vapor, the authors dealt with comparatively high concentrations of this substance (20-60 mg/m^3 or higher), which as a rule are seldom found even under industrial conditions. It was of interest therefore to study the influence of epichlorohydrin on the animal organism in higher concentrations.

To this end, we carried out a continuous inhalational exposure of laboratory animals for 98 days. The tests were conducted on 60 selected white male rats of the same age which were divided into four groups of 15 rats in each.

The animals of the first group were subjected to the action of epichlorohydrin vapor in a concentration of 20 mg/m^3. This concentration is one-half the minimum value studied by Kremneva and Tolgskaya and, according to their data, was found to be close to the threshold concentration in a prolonged but interrupted exposure (3 hours a day).

In the second group, the rats were exposed to epichlorohydrin in a concentration of 2 mg/m^3, and in the third group, to 0.2 mg/m^3, i.e., the highest single maximum permissible concentration for atmospheric air. The fourth group served as the control.

The following factors were observed in the course of the experiment: condition and weight of the animals, change in the latent time of the unconditioned reflex reaction; erythrocytes, leucocytes (including fluorescent leucocytes), hemoglobin, and nucleic acids were determined in the blood, and coproporphyrin was studied in the urine. At the end of the exposure, histopathological analyses of the internal organs of the animals were made.

The numerical data obtained were subjected to statistical treatment by the range method.

Certain characteristics were noted in the behavior of the experimental animals. Thus, on the first day of exposure, the rats of the first group were noticeably excited, and displayed agitation and a considerable mobility. In the next few days the excited state was replaced by depression, which lasted about three weeks. During that time, sluggishness and sleepiness were observed.

The consumption of milk by the animals was somewhat unusual. Whereas, for example, the animals of the third and control groups drank milk for 30-40 min, those of the second group drank the same amount in 1.5-2 hours, and those in the first group, in 4.5-5 hours. This pattern recurred with an exceptional consistency during one and a half months of exposure, and gradually disappeared during the second half of the exposure period.

Observations of the weight dynamics of the rats were made once every two weeks. The weight gain expressed in percent of the original value lagged 14-19% behind the control in rats of the first group toward the end of exposure. Rats exposed to an intermediate and lower concentration of epichlorohydrin developed normally.

At the present time, in evaluating the influence of atmospheric pollutants on the central nervous system of animals, mainly two indicators are used: motor chronaxy of antagonist muscles and conditioned reflex activity.

In our study, we attempted to use a new procedure for this purpose, i.e., the determination of the latent time of the unconditioned reflex reaction.

The indicator used was the motor-defensive reaction in response to stimulation with electric current. The latent time of this reaction was measured with a reflexogenometer proposed by S. I. Gorshkov (1964). The latent time was measured in five rats of each group once a week. During the test, five measurements were made on each rat. An epichlorohydrin concentration of 20 mg/m^3 caused a significant increase in the latent reaction time. This increase occurred 1.5 months after the start of exposure and was observed almost until the end of the exposure period (Fig. 1). No substantial difference in the magnitude of latent time was noted in rats of the second and third groups as compared with the control.

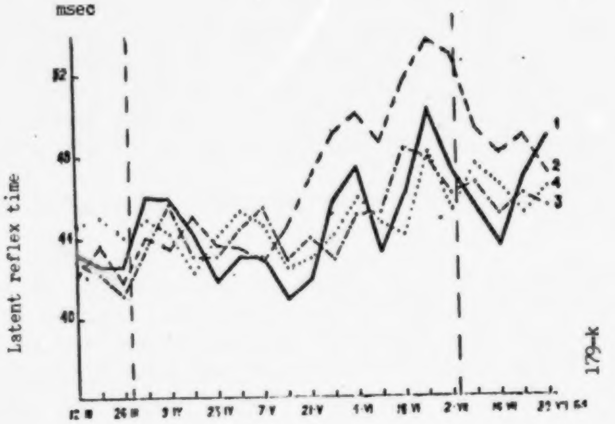

Fig. 1. Effect of epichlorohydrin on the latent time of the motor-defensive reaction of rats of different groups: 1 - control group; 2 - first group; 3 - 2nd group; 4 - 3rd group.

In the last few years, fluorescent* microscopy is finding increasing applications in hematological practice, in particular, in the functional study of the blood system (V. A. Almazov, and S. I. Ryabov, 1963; Ye. B. Zakrzhevskiy and L. G. Vasil'yeva, 1963, and others). This method is based on the ability of ultraviolet as well as blue and violet light to cause the fluorescence of the formed elements of blood treated with special dyes -- fluorochromes. The possibility of using fluorescent analysis of leucocytes for studying the effect of low concentrations of noxious substances present in atmospheric air on the animal organism was first verified by A. D. Semenenko (1963). Shortly thereafter, it was used by M. I. Gusev and K. N. Chelikanov (1963) to substantiate the mean daily maximum permissible concentration of amylenes (pentenes) in atmospheric air.

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* Editor's note: For the Russian terms "luminescent" and "luminescence" in this paper, we have substituted "fluorescent" and "fluorescence" on the basis of the definitions of these terms.

In our studies, the fluorochrome used was acridine orange diluted 1:100,000 in saline solution. The effect of epichlorohydrin was estimated from the amount of leucocytes with altered fluorescence. To this end, 200 leucocytes were counted in each smear, including leucocytes with altered fluorescent properties.

Results of the counts are given in Fig. 2.

The data show that after only two weeks of exposure, an appreciable increase in the number of leucocytes with altered fluorescence took place in rats of the first group. By the sixth week, their amount had increased almost sevenfold as compared with the control, and this was followed by a gradual decrease to the norm. An epichlorohydrin concentration of 2 mg/m^3 also caused statistically significant changes in the amount of fluorescent leucocytes. The percentage of altered leucocytes in rats of the third and control groups was in the range of the background fluctuations over the entire course of exposure.

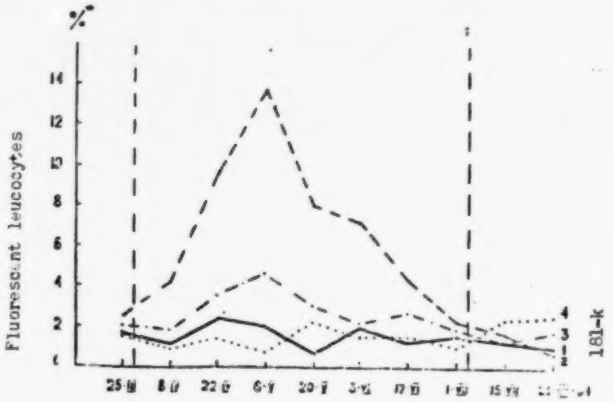

Fig. 2. Dynamics of leucocytes with altered fluorescence in rats exposed to different concentrations of epichlorohydrin. (Notation same as in Fig. 1.)

A study of the composition of peripheral blood did not reveal any substantial difference in the amount of erythrocytes, leucocytes or hemoglobin in the experimental animals as compared with the controls.

Nucleic acids in the blood were determined once every two weeks in five rats of each group using a method proposed by A. S. Spirin (1958).

The method is based on separation of neucleic acids with hot perchloric acid followed by their spectrophotometric determination at two wavelengths (270 and 290 mμ). It was found that epichlorohydrin vapor in concentrations of 20 and 2 mg/m^3 caused a significant decrease in the amount of nucleic acids in the blood. In rats exposed to a high concentration, this decrease was found to be more substantial and occurred much earlier than in animals of the second group. On the average, the amount of nucleic acids in rats of the first group in the course of the last two months of exposure decreased by 22% as compared with the control group. At the end of the recovery period, their content in the blood of animals of both groups returned to normal (Fig. 3).

The chronic effect of epichlorohydrin vapor on metabolic processes in the animal organism was studied on the change of porphyrin metabolism. The amount of coproporphyrin excreted with the urine was determined once every two weeks in five rats of each group using a spectrophotometric method (M. I. Gusev and Yu. K. Smirnov, 1960).

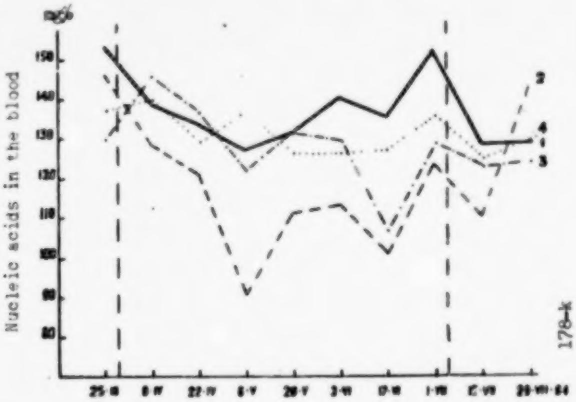

Fig. 3. Change in the content of nucleic acids in the blood of white rats during chronic exposure to epichlorohydrin vapor. (Notation same as in Fig. 1.).

Before the exposure, the daily excretion of coproporphyrin with the urine amounted to an average of 1.4-1.62 μg per 100 g of weight. During the exposure of rats of the first group, the amount of coproporphyrin began to increase rapidly, and in the middle of the second month reached its maximum, 2.68 μg. In the control group, however, the amount of coproporphyrin by that time was 1.07 μg.

Concentrations of epichlorohydrin vapor of 2 and 0.2 mg/m^3 had no significant effect on the porphyrin metabolism.

After the completion of exposure, some of the rats (five from each group) were sacrificed. Histopathological analyses revealed a series of morphologic changes in the tissues of internal organs in rats of the first group. In the lungs, there was emphysema, fine-focus pneumonia, small areas of edema, and loosening and swelling of the adventitia of the blood vessels.

Intermuscular fine-focus hemorrhages and congestion of the veins were noted in the heart, and protein degeneration of the epithelium of convoluted tubules were found in the kidneys. In the central nervous system, there was serious damage to neurons of the myelencephalon, cerebellum, and Ammon's horn of the brain.

In animals exposed to epichlorohydrin vapor in concentrations of 2 and 0.2 mg/m^3, no morphological differences from the control were found in the tissues of the internal organs.

Conclusions

1. Epichlorohydrin in a concentration of 20 mg/m in chronic inhalational exposure causes functional disturbances in white rats (change in the general state, weight lag, lengthening of the latent time of the motor-defensive reaction, increase in the number of leucocytes with altered fluorescence, decrease in the content of nucleic acid in the blood, increase in the amount of coproporphyrin in the urine), and also morphological changes in tissues of the internal organs (lungs, heart, kidneys) and in the central nervous system.

2. An epichlorohydrin concentration of 2 mg/m^3 under the same conditions of exposure affected only certain physiological reactions of the organism (increase in the number of leucocytes with altered fluorescence and decrease in the content of nucleic acids in the blood).

3. A mean daily maximum permissible epichlorohydrin concentration of 0.2 mg/m^3 is recommended in atmospheric air. This concentration was found to be inactive in chronic exposure of the experimental animals.

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